PRIVACY ACT MATERIAL REMOVED

[redacted]

410473

AFSC HISTORICAL PUBLICATION SERIES 61-142-1

UNCLASSIFIED

HISTORY OF AIR FORCE ATOMIC CLOUD SAMPLING

NARRATIVE

JANUARY 1963

RG 342 ~~ATOMIC ENERGY~~

[redacted]

Location Technical Library B-3

Collection AFWL

Folder History of Atomic Cloud Sampling, JAN 1963

NOTE: This is Folder 1 of 2 Containing pages 1 thru 190

~~EXCLUDED FROM AUTOMATIC REGRADING. DOD DIR 5200.10 DOES NOT APPLY~~

CLASSIFICATION CANCELLED WITH DELETIONS BY AUTHORITY OF DOE/OC*

[signature]

REVIEWED BY DATE

*DNA ... 7/23/85

J Diaz 8/19/86

SWEH-2-0034

DELETED VERSION ONLY

[redacted]

AFWL/HO

PRIVACY ACT MATERIAL REMOVED

AUTHORIZATION

This material contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, USC, Sections 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

This document is [redacted] inasmuch as the contents are derived from documents of which the highest [redacted].

This document has been prepared in accordance with provisions of AFR 210-3, AFM 210-1, Editorial Style Sheet for Air Force Military History, and AFR 205-1.

SPECIAL HANDLING REQUIRED
NOT RELEASABLE TO FOREIGN NATIONALS

The information contained in this document will not be disclosed to foreign nationals or their representatives.

SWEH-2-0034

1a

THIS IS A BLANK PAGE

SWEH-2-0034

AFWL/HO

Brigadier General John W. White

SWEH-2-0034

3

AFWL/HO

[redacted]

HISTORY

OF

AIR FORCE ATOMIC CLOUD SAMPLING

VOLUME I

NARRATIVE

by

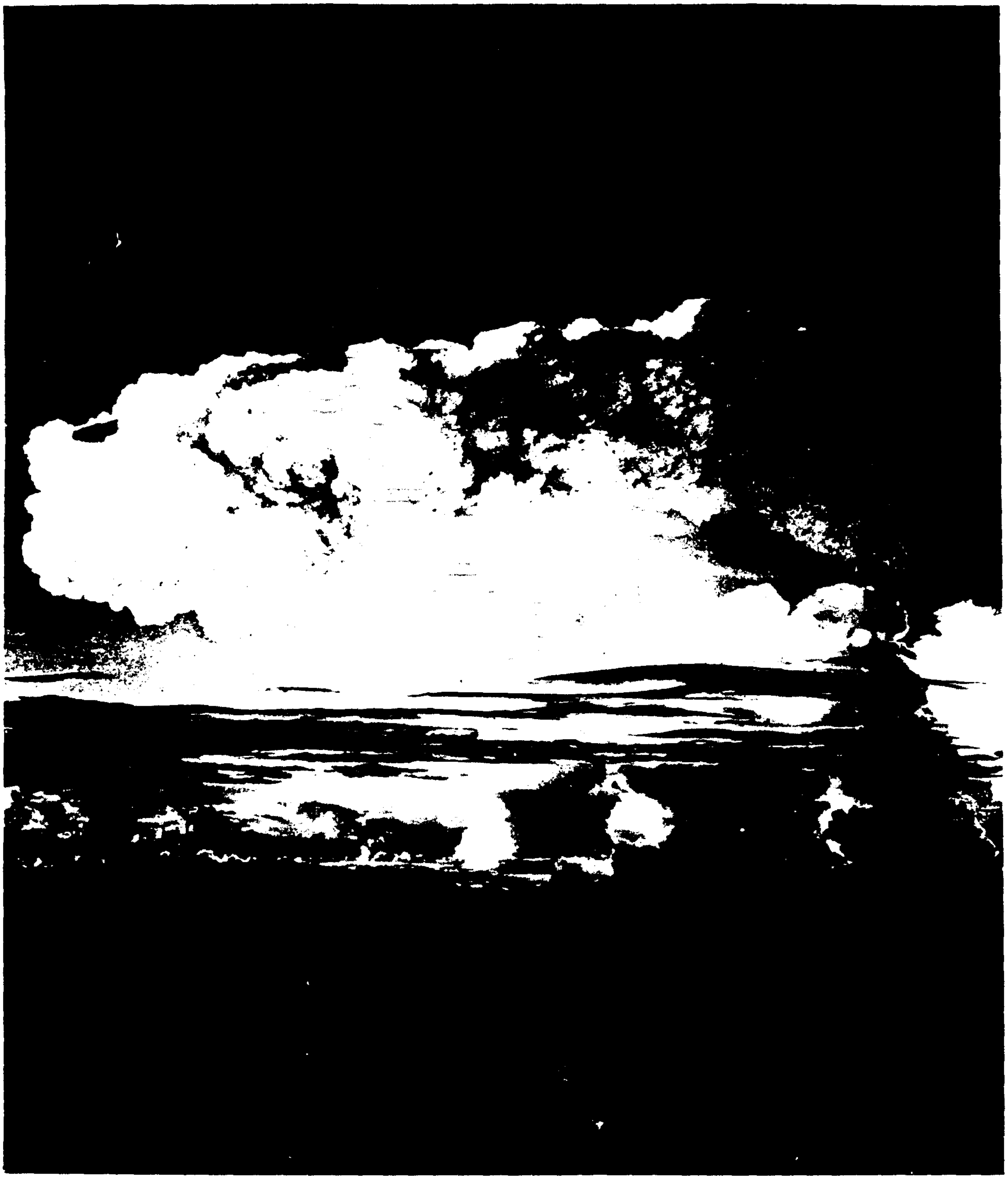
Master Sergeant Leland B. Taylor

Historical Division
Office of Information
Air Force Special Weapons Center
Air Force Systems Command
January 1963

61-142 -1
SWEH-2-0034

[redacted] [redacted]

AFWL/HO



MIKE Shot, Operation IVY

SWEH-2-0034

CONTENTS

VOLUME I

FOREWORD i

INTRODUCTION ii

LIST OF CHARTS AND ILLUSTRATIONS v

CHRONOLOGY viii

I. TESTS PRECEDING MANNED SAMPLING 1
Operation TRINITY 1
Operation CROSSROADS 3
Sampling CROSSROADS 4
Evaluation of CROSSROADS Sampling 13
Operation SANDSTONE 13
Sampling for SANDSTONE 15
Operation SANDSTONE Conclusions 24
Notes 25

II. EARLY MANNED SAMPLING ACTIVITIES 29
Sampling Operation RANGER 29
Operation GREENHOUSE 34
Operation BUSTER/JANGLE 38
Operation TUMBLER/SNAPPER 47
Notes 58

III. OPERATION IVY 63
Aircraft for Sampling 63
Training for Sampler Pilots 66
Sampling Operation IVY Shots 69
MIKE Shot 69
Sampler Aircraft Accident on MIKE Shot 72
KING Shot 75
Radiological Safety During Operation IVY 76
Roll-Up of Operation IVY 76
Notes 77

IV. SAMPLING OPERATION UPSHOT/KNOTHOLE 80
Sampling Planning 80
Sampling the Shots 84
Conclusions 90
Notes 91

SWEH-2-0034

V. OPERATION CASTLE ALL THERMONUCLEAR . . . 93
- Cloud Sampling Requirements for CASTLE . . . 94
- Unmanned Samplers for CASTLE . . . 95
- Modifying Sampler Aircraft for CASTLE . . . 97
- Sampling CASTLE Shots . . . 103
- Notes . . . 118

VI. OPERATION TEAPOT: CONTINENTAL SAMPLING . . . 121
- Sampling Highlights . . . 122
- The High Altitude Nuclear Shot . . . 130
- Notes . . . 137

VII. OVERSEAS FOR OPERATION REDWING . . . 139
- Plans and Operations . . . 139
- Shots and Aircraft Participation . . . 145
- Radiation Safety and Monitoring . . . 150
- Flight Safety Test Area . . . 151
- Determining Aircraft Positioning Responsibility . . . 152
- Notes . . . 155

VIII. OPERATION PLUMBBOB, A NEW ORGANIZATION . . . 158
- Mission of the 4950th Test Group (Nuclear) . . . 158
- Manning the 4950th Test Group (Nuclear) . . . 159
- Operation Planning . . . 161
- Aircraft Requirements . . . 165
- Sampling Plans . . . 167
- Shots and Aircraft Participation . . . 168
- Notes . . . 173

IX. OPERATION HARDTACK AND DUAL SHOTS . . . 174
- Shot and Aircraft Participation: Phase I . . . 182
- Shot and Aircraft Participation: Phase II . . . 186
- Advantages of Experience . . . 191
- Notes . . . 196

X. NUCLEAR CLOUD SAMPLING . . . 198
- Quantitative Considerations . . . 200
- Characteristics of Clouds . . . 201
- Cloud Heights and Sampling Altitude . . . 203
- Radiation Characteristics of Primary Clouds . . . 205
- Estimation of the In-Cloud Radiation Exposure Required . . . 206
- Radiation Exposure Received During Return to Base . . . 211
- Some Observations on Techniques . . . 212
- Notes . . . 227

XI. RADIATION PRECAUTIONS . . . 229
- Notes . . . 240

XII. SUITABLE SAMPLING AIRCRAFT 242
Notes 257

XIII. THE 4926TH TEST SQUADRON (SAMPLING) 261
The Test Aircraft Unit (TAU) 267
Recent Special Assignments 280
KIWI 288
SUNDAY PUNCH 290
MUSIC MAN 291
GOLF BALL 292
Squadron Transferred to Military Air Transport Service 292
Notes 296

APPENDIX I: A LIST OF AIR FORCE SAMPLING PERSONNEL 300

APPENDIX II: LIST OF SAMPLES TAKEN FOR EACH SHOT 303

GLOSSARY OF ABBREVIATIONS 306

GAZETTEER 316

GLOSSARY OF TERMS 319

INDEX 330

THIS IS A BLANK PAGE

SWEH-2-0034

9.

AFWL/HO

FOREWORD

Aircraft sampling of atomic clouds became one of the great flying adventures of all time. Scientific analyses of cloud debris required retrieval of this material from every feasible continental and overseas test shot and represented in the fantastic activity were not only the 4926th Test Squadron (Sampling) but also many flyers, scientists, and support groups, both military and civilian. In this respect, the subdued style of this history obscures a multitude of personalities and experiences which if included would have overdrawn resources at hand and delayed the publication of the sampling story indefinitely. It is intended, on the other hand, that this volume will serve both as a history and a guide. There is included certain instructions in graphic detail, general problems are examined carefully, such as scheduling, requisitioning material, and aircraft and personnel under conditions of radiation, so that newcomers might not be totally unfamiliar with sampling as it was done in the past.

On 16 August 1961, the 4926th Test Squadron (Sampling) transferred from the Air Force Special Weapons Center, to become a part of Air Weather Service, Military Air Transport Service. Along with the transfer went many years of experience and profitable relationships among the Center and agencies of the Department of Defense. A part of that story is also brought up-to-date as a tribute to the people who participated in this invaluable service toward developing the nuclear genie.

Ward Alan Minge
WARD ALAN MINGE
Center Historian

INTRODUCTION

Undertaken at a time when atmospheric testing of nuclear weapons or devices had been discontinued for more than two years, this monograph was to be a record of nuclear cloud sampling. Prior to completion of the compilation of documents, interviews, and the writing of the narratives, the Russians had started atmospheric testing and the United States had resorted to underground testing. As this history was concluded, DOMINIC was underway and the sampling story continued.

From the opening chapters the transition is toward a "problem-solving" attitude. The problems which appear in the early tests are not the problems of later tests; the solutions to the problems of the later tests appear to have potential future use, therefore they are discussed in detail. Emphasis has been placed on presenting the solutions to problems unique to the sampling effort. Nevertheless, the chronicling of the cloud sampling effort cannot be completely divorced from the entire nuclear testing activities.

Basically, the text contains information which all of those directly associated with nuclear cloud sampling or with decontamination of aircraft should have knowledge. It is hoped that a study such as this will result in an increase in the understanding of the need for nuclear cloud sampling; that in turn, will result in an increase in the "motivation" level of those called upon for participation in future sampling efforts.

Except in such sections as are inherently technical in nature, a concerted effort has been made to reduce technical terms and phraseology to understandable levels. Those readers who may be required to engage in direct efforts associated with the sampling of clouds will gain an understanding of the over-all complexity of the sampling mission and will realize the importance of their specific tasks or missions.

Preparation of the chapter HARDTACK was made extremely difficult because so many of the documents were in use at Johnston Island by those implementing Operation DOMINIC. It is regrettable that this work could not have been completed and published soon after the conclusion of HARDTACK. It could then have been used as a primary reference source in planning DOMINIC, with due regard to the technical contents of the referenced specialized documents available from the Historical Division files. Fortunately, many of the documents used in compiling this special study were assembled by a former member of the Air Force Special Weapons Center historical staff, Mr. Warren Greene. Had Mr. Greene not secured these documents when he did, much of the story would have been lost. Unless designated as being physically located elsewhere, all documents referred to are in the files of the Air Force Special Weapons Center Historical Division. They are available to authorized individuals wishing to study their contents; it is possible that copies may be loaned when requested through proper procedures.

The informality and approved direct-communication rules which were in effect during the earlier nuclear tests enhances the value and interest of the documentation used. The correspondents, protagonists and antagonists, in the rare disagreements which arose, regardless of the symbols of rank worn on shoulders or the scientific status held, were all human beings. It is doubtful that a serious student could peruse those communications without becoming infected with some degree of hero worship as concerned many of the principals who engaged in the awesome task of nuclear testing.

It is regretted that insufficient credit is given to the pilots who gathered the nuclear debris. Nor do the primary or secondary sources give sufficient information concerning those rare individuals. The scientists from "The Hill" (Los Alamos Scientific Laboratory) who gave me such valuable assistance in compiling this work, emphatically expressed their opinions of the high and unusual calibers of the sampling pilots. From Los Alamos, I am particularly grateful to Paul Guthals and Philip Moore who read the manuscript with a critical eye. Valuable assistance was given by Colonel Paul H. Fackler who has had a guiding hand in sampling from the early days and Captain Gordon E. Stalcup, historian for the 4926th Test Squadron (Sampling); many members of the staff of the Air Force Special Weapons Center Technical Library, and by Ward Alan Minge, Air Force Special Weapons Center Historian. Mr. Minge was particularly helpful and patient in the guidance necessary for converting journalistic habits of writing into historical form.

LELAND B. TAYLOR
Master Sergeant, USAF

LIST OF CHARTS AND ILLUSTRATIONS

Title — Page

Brigadier General John W. White . . . . Frontispiece

Colonel Paul H. Fackler 31

Airmen Monitor B-29 Sampler During Decontamination Procedures, Operation BUSTER/JANGLE 43

Harold F. Plank, Los Alamos Scientific Laboratory, Expert on Sampling Techniques and Veteran Radiological Officer . . 57

Instrument Panel F-84G Sampler Aircraft 68

Aircraft Pattern for Collecting Cloud Sample, Operation IVY . 68

Chart: Shots for UPSHOT/KNOTHOLE 86

Inserting Filter Unit into Tip Tanks of a Sampler Aircraft, Operation UPSHOT/KNOTHOLE 88

Chart: Operation CASTLE Schedule at Bikini Atoll 104

Decontaminating B-36 Sampler Aircraft, Operation CASTLE . . . 108

Decontaminating B-36 Sampler Aircraft, Operation CASTLE . . . 110

Preparing "Hot" Samples for Delivery to the Laboratory, Operation CASTLE 113

Rolling Sample Paper for Insertion into Lead Pig, Operation CASTLE 115

Sampling Paper is Inserted into Lead Pig, Operation CASTLE . 116

Lifting Loaded Pigs for Transfer to Waiting Delivery Aircraft, Operation CASTLE 116

Atomic Cloud as Seen from Plane, Operation TEAPOT 123

Chart: Operation TEAPOT Schedule 125

Decontaminating the B-29, Operation TEAPOT 131

Airman Thomas O. Summers, 4926th Test Squadron (Sampling), Demonstrates Removal of a Filter from the Wing Tip of an F-84 Sampler, Operation TEAPOT 131

Soaping a B-47A Sampler Aircraft, Operation TEAPOT 132

4926th Test Squadron Pilots in front of B-47 Sampler, Operation TEAPOT 135

Sampling, Idealized Cloud 142

Sampling Chronology 142

Diagram of Wing-Tip Filtering System 144

Sample Recovery Flow 144

Rad Safe Personnel Boarding Plane, Operation REDWING . . . 151

Colonel Carl A. Ousley, Test Aircraft Unit and Dr. Harold F. Plank, Scientific Director, Sampling Program, Operation PLUMBBOB, Check Sampling Mission with Major Malcolm S. Bounds, Commander, 4926th 162

Airman Buford Jackson, Radar Operator, 4950th Test Group (Nuclear) Uses Control Point Board to Record Position of F-84 Sampling Aircraft, Operation PLUMBBOB 168

Chart: Schedule for Operation PLUMBBOB 169

B-57 Sampler, Operation HARDTACK 178

15

Chart: Sampling HARDTACK, Phase I 182

Chart: Sampling HARDTACK, Phase II 186

Outstanding Unit Award Ceremony, 4926th Test Squadron, (Sampling). 278

Change of Command Ceremonies, 4926th Test Squadron, (Sampling). 295

16

CHRONOLOGY

16 July	1945	First nuclear device exploded at Trinity, New Mexico, introduced the atomic weapon era.
6 August	1945	Atomic bomb dropped on Hiroshima, Japan.
9 August	1945	Atomic bomb dropped on Nagasaki, Japan.
-- July	1946	Operation CROSSROADS conducted at Bikini Atoll in Pacific.
April-May	1948	Operation SANDSTONE conducted at Eniwetok Atoll in Pacific.
January-February	1951	Operation RANGER conducted at Nevada Proving Grounds.
October-November	1951	Operation BUSTER/JANGLE conducted at Nevada Proving Grounds.
1 April	1952	Special Weapons Command, redesignated Air Force Special Weapons Center, became part of the Air Research and Development Command.
April-June	1952	Operation TUMBLER/SNAPPER conducted at Nevada Proving Grounds.
1 July	1952	Indian Springs Air Force Base transferred from Air Training Command to Special Weapons Center.
--November	1952	Operation IVY conducted at Eniwetok Atoll in Pacific.
March-June	1953	Operation UPSHOT/KNOTHOLE conducted at Nevada Proving Grounds.
March-May	1954	Operation CASTLE conducted at Eniwetok and Bikini Atolls in Pacific.
11 May	1954	Air Research and Development Command directed the Special Weapons Center to undertake air-to-air nuclear warhead rocket development.

February-May	1955	Operation TEAPOT conducted at Nevada Test Site.
May-July	1956	Operation REDWING conducted at Eniwetok and Bikini Atolls in Pacific.
21 May	1956	CHEROKEE Shot, first American airdrop of a megaton weapon, performed over Charlie Island, Bikini Atoll.
1 September	1956	Activation of the 4950th Test Group (Nuclear).
27 November	1956	Joint Task Force SEVEN published planning schedule for Operation HARDTACK.
--December	1956	Special Weapons Center began planning for ultra high altitude shot of the HARDTACK series.
1 January	1957	Air Defense Command began limited emergency [redacted] rocket capability.
29 April	1957	Preliminary "book message" constituting authority for Air Force commands to begin initial planning for Operation HARDTACK issued by Air Force headquarters.
May-October	1957	Operation PLUMBBOB conducted at the Nevada Test Site.
19 July	1957	JOHN Shot fired at the Nevada Test Site; first live firing of an [redacted] air-to-air nuclear warhead.
1 October	1957	Headquarters, Task Group 7.4 (Provisional), for Operation HARDTACK designated and organized at Kirtland. This action provided for two major subordinate units; Test Aircraft Unit, Provisional, at Kirtland, and the Test Base Unit, Provisional, at Eniwetok.

6 January	1958	Operation Plan 1-58 for HARDTACK provided Task Group 7.4 elements a firm basis for detailed planning activities.
28 April	1958	YUCCA Shot, launched by balloon, initiated Operation HARDTACK series when it fired approximately 60 miles northeast of Eniwetok.
30 October	1958	TITANIA Shot, safety experiment fired from a 255-foot tower. This was the last shot of Operation HARDTACK, Phase II.
31 October	1958	President Eisenhower's nuclear test moratorium to become effective for one year.
24 September	1959	SUNDAY PUNCH, continuing world-wide sampling.
7 January	1960	GOLF BALL.
8 July	1960	KIWI-A PRIME, Jackass Flats, Nevada.
22 August	1960	MUSIC MAN.
10 October	1960	KIWI-A THREE.
16 August	1961	4926th Test Squadron (Sampling) transferred to Military Air Transport Service and redesignated 1211th Test Squadron (Sampling).

[redacted]

CHAPTER I

TESTS PRECEDING MANNED SAMPLING

Perhaps the biggest thing to come out of the Second World War was the development of nuclear energy. The intensive program which resulted in making this energy available was climaxed by the detonation of the world's first atomic explosion near Alamogordo, New Mexico, in July 1945. Compared with later programs, the Alamogordo test was a very primitive affair. Although the cloud itself was a factor in planning the test and several B-29 bomber aircraft were airborne, on this first test no samples were taken from the atomic cloud. Crater samples were taken instead.[1]

<u>Operation TRINITY</u>

By mid-1945 the Manhattan Project scientists, working at Los Alamos Scientific Laboratory, developed LITTLE BOY and FAT MAN. The latter was chosen for the TRINITY test.[2] During the dramatic preparations for the explosion, the Manhattan Project people had their theories pretty well worked out[3] but there were a number of areas where speculation on the possible results of the TRINITY were made. Some of the scientists considered the possibility of setting off a chain reaction with the bomb which could not be controlled. What if the chain reaction did not stop with the material in the bomb, but continued on through the surrounding atmosphere?[4] At the same time, the expected cloud from the TRINITY shot was the subject of some attention. Professor J. O. Hirschfielder, of the Laboratory, wrote: "Calculations which I have made on the smoke column would indicate that the radius of our smoke column would be of the order of 500 to 100 meters therefore we would not expect to poison an area of more than a few square kilometers."[5] Professor Hirschfielder also proposed that FAT MAN be fired during weather conditions "conducive to thunderstorms," which would reduce the radioactive fallout from the "smoke column."[6]

Possible dangers from the radioactive cloud following the shot were unknown. Therefore, precautions were taken to protect the unsuspecting population near the test site. On Sunday evening, 15 July 1945, a convoy of Army trucks parked along a road just outside the small town of Carrizozo, New Mexico, northeast of the test site. The convoy commander was in contact with the test operations by radio and, if the nuclear cloud drifted over the little town, the truck convoy was to enter Carrizozo and evacuate the citizens.[7] Just before daylight on Monday, 16 July 1945, the first atomic bomb detonated with an energy release of approximately 23.8 kilotons.[8] Two Sherman medium tanks, with Army crews approached the crater following detonation and measured the radiation. They had been modified for sampling; a scoop operated from the interior of the tank and the interiors were lined with lead. Professor Enrico Fermi was in one of these sampling tanks, supervising the operation. Crews lowered the scoops and obtained dirt for laboratory analysis. This constituted sampling mission for Operation TRINITY.[9] But the scientists were well satisfied with the TRINITY test. The bomb ". . . was as powerful as any had dared hope and it was a practical weapon."[10]

I

Operation CROSSROADS

During Hiroshima and Nagasaki, no attempt was made to collect samples of any type. These were the only nuclear detonations made by the United States which did not have some samples taken. They were followed in July 1946, by Operation CROSSROADS, the first of many elaborately planned and conducted tests on the new energy. During CROSSROADS, the debris from an atomic cloud was sampled by aircraft for the first time.[11]

The greater part of the Operation CROSSROADS program involved the United States Navy. From target arrangement to support units, the operation was almost entirely Navy with naval personnel filling 90 per cent of the posts.[12] On 29 December 1945, the Joint Chiefs of Staff appointed Vice Admiral William H. P. Blandy, an ordnance specialist, to command Task Force One, the organization which would conduct the tests. President Truman, on 10 January 1946, approved the appointment and, the next day, the Task Force was activated.[13]

Air operations for CROSSROADS was commanded by Major General W. E. Kepner, Army Air Forces. General Kepner had wide experience in aviation commands and was familiar with both Army and Navy air activities.[14] Admiral Blandy organized a number of task groups for specific functions, a practice which was continued through nuclear test programs including the overseas tests conducted ten years later in 1956.[15]

Under the Task Force, the Army Air Forces established Task Group 1.5, commanded by Brigadier General R. M. Ramey. General Ramey's Task Group was responsible for all Army Air Force activities during Operation

CROSSROADS and the 58th Wing of the Fourth Air Force was designated Headquarters, Task Group 1.5 (Provisional).[16] From this organization came the staff for the test group. The 509th Composite Group and Roswell Army Air Field transferred to the Fourth Air Force from the Second. It had dropped the two atomic bombs on Japan during World War II. The 58th Wing then transferred from March Field, California, to Roswell. There an intensive training program was instituted. Each unit concentrated on its special mission, with the highest priority being given to the bombing aircraft unit, the 393rd Bombardment Squadron. Bombing ranges near Albuquerque and Alamogordo were used heavily and Clovis Army Air Field as a satellite training field for Task Group 1.5 (Provisional) where the world's first atomic cloud sampling was in preparation with drone aircraft.[17]

Sampling CROSSROADS

Operation CROSSROADS saw the beginning of Air Force atomic cloud sampling with drones because of the unknown dangers. Manhattan Project sampling requirements included tiny portions of the debris contained in the atomic cloud which represented what was actually contained in the cloud. One of the biggest worries for the scientists at that time was that fractionation would take place. Fractionation was the physical change in the distribution of debris particles collected and could give false impression of what the cloud contained. "With no experience to fall back on," William Rubinson, a Los Alamos scientist, wrote, "All that one can do is to collect as many different samples in as many places and as many ways as possible, and devise what means he can of testing whether fractionation has occurred. A silent prayer is then made that no fractionation will occur." Fractionation occurring naturally within the cloud and that caused by the characteristics of the sampling device employed, constituted two types of fractionation. Manned sampling was at some disadvantage in the first type because of the necessarily later penetrations.

One method of testing for fractionation, Rubinson added, was with samples collected by radio-operated drone boats. Soon after the CROSSROADS detonations, drone boats would move in to collect water samples. After a period of time, other drone boats would go into the target area to collect more samples. If the later samples matched the earlier ones, Mr. Rubinson reported, ". . . then we could be sure that no fractionation had occurred between the time of the shot and time the first samples were collected."* Under the circumstances, Rubinson wished for as many cloud samples as could be taken. For the airburst, he asked that cloud samples be taken from eight different altitudes with only four altitudes during the water detonation.[18]

Task Unit 1.5.3. The Instrumentation and Test Requirement Unit, Task Unit 1.5.3, was charged with taking samples from the atomic clouds during Operation CROSSROADS. The unit organized at Clovis Army Air Field,

*Results of the water sample tests indicated that some fractionation had taken place.

New Mexico, on 1 February 1946, and consisted of people from technical sections of the Air Materiel Command, at Wright-Patterson Air Base, who had been engaged in development of drone operations. There were also a number of experienced B-17 bomber crews in the unit.[19] In this context, the Army Air Forces Drone Unit had four B-17 drone aircraft, four B-17 drone control aircraft, and one B-17 master drone aircraft. They were equipped with air filters and air collection bags for gathering debris.[20] Box-like filter holders were mounted on the top and bottom of the drone aircraft fuselage. Into these fitted two thicknesses of filter paper which admitted 90 cubic feet of air through them. Each drone had a larger rubber bag which could capture 90 cubic feet of air. These bags were opened for thirty seconds while the drone passed through the cloud, then closed. In addition, the engine air intake filters on the drones were removed after a flight and tested for radioactive debris, although this method produced very little radioactivity.[21] The drones also carried cameras to record the growth of the atomic cloud at close range.[22]

Air Materiel Command technicians began an intensive training program at Clovis Army Air Field to enable B-17 bomber crews to handle drone aircraft. Special courses in the use of radio-controlled equipment were instituted and preparation for an activity never before attempted. Drone aircraft had been operated before by remote control, but during the drone training program, safety pilots were aboard to prevent loss of these specially modified aircraft.[23] The Task Unit 1.5.3 accomplished its first training mission on 11 February 1946, and by 15 February 1946, the first B-17 pilots began training in radio-controlling of drones from the ground and from other B-17 aircraft in flight. The flight training stressed long-range navigation, cruise-control, radio-controlled landings and takeoffs, and both high and low altitude missions in order to achieve coordination between the control aircraft and the drones. Much time was devoted to ground approaches and to developing standard operating procedures for all phases of drone control and operations. Sixteen B-17 crews completed drone flying training during which they accumulated some 138 hours of flying and 90 hours of ground training.[24]

Late in April 1946, the Army Air Forces began moving to the Pacific for the operational phase of CROSSROADS. The echelon of Task Unit 1.5.3 left Clovis Army Air Field from 19 to 23 April 1946, and flew to Hamilton Field, California, to Hickam Field, Hawaii, to Johnston Island and to Eniwetok. The water echelon arrived in the islands aboard the Rockinham and all personnel of the unit were in place by 6 May 1946. Headquarters for Task Group 1.5 was on Kwajalein, while the drone unit, along with part of the air-sea-rescue service, was at Eniwetok.[25]

Drone flight training immediately resumed in the Pacific area with eight practice missions flown between 14 May and 24 June 1946. Six of these practice missions were dress rehearsals for all air units of the Task Group; one mission was for the drone aircraft alone; and one was a dress rehearsal which cancelled after the drones were already on station. Altogether, the drone aircraft unit flew some 610 hours of practice before the first shot of the series.

At first, the main problem encountered during the training period was coordination between the ground controllers, who landed and launched the aircraft from control jeeps, and the airborne controllers who flew the drones from other B-17 control airplanes. During the training on Eniwetok the ground drone operators controlled 124 takeoffs and made 140 landings with the B-17 drones. The airborne controllers totaled 89 flights during the same period.[26] During all these practice missions a safety pilot sat in the drone aircraft. On one occasion the safety pilot prevented the drone B-17 from crashing on takeoff. On another occasion the drone went into a steep climb just after clearing the runway and the safety pilot straightened it out before the airborne controller, in a control B-17, took over the flight of the drone. On another occasion a corroded antenna snapped on a drone, which would have been lost had the safety pilot not been aboard to land the aircraft. As these malfunctions occurred, the drone unit technicians and mechanics corrected the trouble and experienced what to watch for in other drones.[27]

Sampling ABLE Shot. On the last day of June 1946, word circulated that the first atomic bomb of the series was to be dropped the next morning. During the night, crews swarmed over the drone aircraft, making final adjustments. At about 0130 on the morning of 1 July 1946, the first of some 85 aircraft took off to participate in the test. On Eniwetok, ground control pilots in radio jeeps sent the four B-17 drones off on schedule. The four control B-17 aircraft took over the drones and climbed them to their assigned altitudes, where they began a programmed pattern while waiting for the B-29 aircraft to drop the bomb. A fifth B-17 bomber, the master control aircraft, also circled with the others over Bikini Lagoon.[28]

A command aircraft, with and aboard, circled over the test area on the lookout for any last minute changes to the air pattern while the B-29, arriving with the bomb, reported bombs away and at approximately 0900 ABLE exploded over the target fleet.[29] At this point, the control aircraft, MARMALADE TWO, turned its B-17 drone, FOX, toward the rising cloud at an altitude of 24,000 feet. As the drone neared the atomic cloud, MARMALADE TWO released it on automatic pilot and drone FOX entered the cloud about eight minutes after explosion. MARMALADE TWO speeded up, circling around the cloud carefully, and when FOX drone came out the other side, again took command and began the trip back to Eniwetok.

At 0920 GEORGE drone entered the cloud at 30,000 feet altitude. The control B-17 was heavily loaded with fuel and, when it had circled the cloud, GEORGE drone had already come out and was headed away. The master drone control aircraft then took control of GEORGE until the control aircraft caught up. At 0921 HOW drone entered the cloud followed by LOVE drone at 0922. Both were recovered by their control aircraft.

The four B-17 drones were flown back to Eniwetok and turned over to the drone controllers in jeeps at the end of the runway. All four drones landed and taxied to the radiological safety area. Radiologists and project personnel removed the air bags and fuselage filters, loaded them aboard a transport aircraft, and flew them to Kwajalein for laboratory tests. The GEORGE and FOX drones, first two through the cloud, were especially "hot."

The ABLE test sampling mission proved to be a success. For the first time samples were taken from an atomic bomb cloud. Also, for the first time, four-motored drone aircraft had been flown without a safety pilot aboard.

Sampling BAKER. BAKER Shot came on 25 July 1946. During the intervening time, the drone aircraft unit kept busy for an additional requirement, performing necessary precision flying. Top test officials decided that two of the B-17 drones, FOX and GEORGE, would be directly over the BAKER detonation. This called for extremely accurate flying to position the aircraft and the unit flew daily missions over Bikini or Eniwetok preparing for the mission. A radio beacon on the target ship aided the drone controllers in positioning.[30]

On the morning of 25 July 1946, jeep radio equipment launched these two drones which were taken over by their drone control aircraft and flown to an area west of the target ship, with Boro Island as the reference point for making their run on the target. While waiting for the shot to go off, drones FOX and GEORGE underwent two practice passes across the target ship. The radio beacon on the target was of great aid in placing the aircraft.[31]

Seconds before BAKER Shot, drones FOX and GEORGE started their live runs over the target ship. FOX drone flew at 6,000 feet altitude and GEORGE drone was at 16,000 feet. On board GEORGE was a television camera, aimed at the target ship, which transmitted to the test control ship recording the pictures.[32] Timing was just right. When the bomb exploded in the water, FOX drone was almost directly overhead. Five seconds later, the shock wave caused FOX drone to gain about 60 feet altitude, the bomb doors warped, all inspection plates blew off, the tail gunner's escape hatch blew inside the aircraft, the canvas covering over the tail wheel well split,and standard aircraft cushions inside the aircraft bursted. Drone control was maintained throughout, however. Ten seconds after the blast, the shock wave struck GEORGE, 16,000 feet over the target. GEORGE gained 300 feet from the shock wave, but sustained no visible damage. Both aircraft responded to directions and landed safely on Eniwetok.[33]

Drone HOW passed through the atomic cloud at 7,000 feet on a sampling run five minutes and eight seconds following detonation. At seven and one-half minutes after the detonation, drone LOVE went through the center of the cloud at 11,000 feet. Returning to Eniwetok, drone LOVE got away from its control aircraft and, after a call for help, the master control aircraft regained control.[34] Three of the B-17 drones landed at Eniwetok without incident, but drone HOW lost its brakes on landing, went off the end of the runway, and sustained some damage.[35]

When Manhattan Project scientists later removed the samples from drones HOW and LOVE, they discovered that the HOW sample was too weak. Only the LOVE sample and one Navy drone sample were of any value.[36]

Task Unit 1.6.1, Navy Drones. A Navy drone unit also collected samples from the atomic clouds during Operation CROSSROADS. Organized at the Naval Air Station, Atlantic City, New Jersey, on 26 January 1946, it had 30 drone F6F-3Ks and 26 drone control F6F5s. On 7 March 1946, the unit boarded the aircraft carrier, Shangri-La, at Norfolk, Virginia, and arrived at San Diego, California, on 1 April 1946, for training at Brown Field, Naval Auxiliary Air Station, Chula Vista, California.[37] When the Shangri-La sailed from San Diego, the Navy Drone Unit had four F6F drones modified to collect samples. In the Marshall Islands, the drone aircraft landed on Roi Island, base of operations. While waiting for ABLE, the Navy drones accomplished 139 takeoffs from the decks of the Shangri-La, with 110 catapult launchings. The unit also accomplished 87 drone landings on the carrier deck.[38]

On shot day, the Navy Drone Unit had its airplanes in the air on station. A few minutes before detonation, one of the four F6F drones suddenly went out of control, dived away from its mother ship, and crashed into the sea. The other three drones went through the cloud and returned safely to Roi Island where the Manhattan Project personnel removed the samples.

For BAKER Shot, the drones carried cameras. In the 24 days between shots, the Shangri-La launched drones 493 times. Only one accident marred the Navy's training program. During a routine training flight from Roi Island on 9 July, a Navy drone with a safety pilot aboard, suddenly rolled at very low altitude and dived into the sea. Both the airplane and pilot were lost. Otherwise, BAKER operations went off without incident, the drones passed through the cloud, then landed on Roi Island where the samples were removed.[39] However, only one of the three F6F drones returned with a usable sample.[40]

Evaluation of CROSSROADS Sampling

The Manhattan Project scientists left no doubt they had received valuable information from the sampler drones during Operation CROSSROADS. Sampling papers from both shots were good, although only one B-17 and one F6F got samples on BAKER Shot. Subsequent chemical tests indicated that no fractionation had taken place.[41] The rubber air bags, carried aboard the B-17 drone aircraft worked very well for collecting samples. They had been opened for about 30 seconds while in the cloud, and scooped up air and debris samples. However, technicians were unable to use these because ". . . we were unable to learn in time how to get the activities out of the bag without fractionation."[42] Finally, a B-29 tracked the atomic cloud in an attempt to sample if all other methods failed. On ABLE Shot the B-29 attempted a sample several hours after the shot, but the radiation intensity was barely detectable.[43]

After a look at the data back at Los Alamos, Mr. Rubinson made these recommendations for future attempts to sample nuclear clouds:[44]

> If it is at all possible, samples should be collected by the drone air filter method. These were our most reliable samples, . . . It should also be important to try to collect a sample about 24 hours after shot, with precipitron on a B-29, in order to see if an accurate efficiency determination is feasible with such a sample.

Operation SANDSTONE

The following spring, on 3 April 1947, the Los Alamos Scientific

32

Laboratory proposed a new atomic test series,[45] which the newly established Atomic Energy Commission submitted to President Truman who approved the series on 27 June 1947. Detailed plans were drawn up with approval from the Joint Chiefs of Staff on 16 October 1947. Two days later, on 18 October, Joint Task Force SEVEN formed to conduct the tests with Lieutenant General John E. Hull, United States Army, as Commander, while Major General William E. Kepner received command of all aerial units, the same duties he had performed during Operation CROSSROADS.[46]

Although Task Force SEVEN became official on 18 October 1947, various units began operations before that date. On 8 October 1947, the United States Air Force, not yet a month old, directed the Strategic Air Command to organize, equip, man, and train an Air Task Group for the new series, Operation SANDSTONE. At the same time, the Air Materiel Command, Air Proving Ground Command, and the Air Transport Command were to give support. Eighth Air Force of the Strategic Air Command had the duty of procuring personnel and organizing Task Group 7.4.[47] On 16 October 1947, Brigadier General Roger M. Ramey, was again called upon to command the task group. which was to gather cloud samples and shock wave measurements with drone aircraft, operate photographic aircraft, long-range weather reconnaissance aircraft, cloud tracking aircraft, air-sea rescue aircraft, inter-island air transportation, emergency air evacuation for Eniwetok, if needed, and aircraft to transport radiological safety monitors, and radiological sample materials.[48]

Official organization of Task Group 7.4 took place at Fort Worth, Texas, on 9 January 1948.[49] Copies of the reports from Operation

CROSSROADS were obtained from Air Force histories so that Task Group 7.4 staff members could read about problems encountered during the former test. A significant change occurred with the new operation as security classification became much tighter. Also, obtaining supplies and qualified personnel was much more difficult in 1948 because the war was sometime passed and military services were operating at a low ebb.[50]

Sampling for SANDSTONE. At this time, Colonel John R. Kilgore commanded the First Experimental Guided Missiles Group, Eglin Air Force Base. On 14 July 1948, Major General William L. Richardson, Chief of the Guided Missiles Division, Air Force headquarters, wrote the Colonel requesting information about the Group's capabilities to train and make available either B-17 or B-29 aircraft for special drone missions. After studying the problem, Colonel Kilgore's people concluded that it would take about two years to develop the B-29 for drone operation. Emphasis shifted to B-17 aircraft when on 15 August 1948, General Richardson visited Eglin Air Force Base to discuss support for a drone operation similar to that conducted during Operation CROSSROADS. The first talk assumed that 10 drone B-17 aircraft and 6 control aircraft would be needed. Colonel Kilgore believed his group could handle the job and preparation of the sampler drones for SANDSTONE got under way. However, on 8 December 1948, the drone requirement changed. Colonel Kilgore was to supply 12 samplers and 12 control B-17 aircraft.[51]

The drone unit, Task Unit 7.4.2, had the most serious training problem in Task Group 7.4 because of the peculiarities of its mission. Personnel often had to be trained "from scratch" on the complicated electronic equipment used in the drones. Also, there was serious shortage of "beeper" pilots to control the drone aircraft. Officers who had experience with drone aircraft operations were called back into service and others were put into training for drone operations. An excellent aircraft pilot, the drone unit soon discovered, might be unable to develop proficiency as a "beeper" pilot. Therefore, a large number of pilots entered into the "beeper" training.

There also was a problem in securing and training maintenance personnel for the drone unit's communications and electronics equipment. Besides a lack of qualified personnel, there was not enough space to conduct the training, equipment was lacking or inoperative, and power supplies for the equipment on hand was inadequate. In some cases individuals had been assigned to the unit for maintenance training after the outfit had packed up for the move overseas to the test site.[52]

The drone unit's training program also caused a security problem. No information had been given out regarding the impending Operation SANDSTONE tests. However, Colonel Kilgore searched the entire Air Force to locate all personnel who had helped operate drones during CROSSROADS. When these "old hands" arrived at Eglin Air Force Base they recognized the preparation soon enough and concluded that another nuclear test operation was under way.[53]

Twenty-four B-17 aircraft were prepared for SANDSTONE sampling, half of them drones and half of them control planes. This allowed for 50 per cent spares in the program.[54] Each of the B-17 drones carried two air filter boxes, one located on top of the aircraft's cabin, just back of the pilot's seat, and the other under the nose of the aircraft. The filter boxes were removed by pulling a lanyard attached to locking pins. The lanyards were secured to the aircraft fuselage during flight and were handy to ground crews. The drone unit personnel built a special rig with which to lift the top filter box from the aircraft. The bottom filter holder was allowed to drop to the ground when the lanyard was pulled. Atomic Energy Commission personnel then dragged the boxes some fifty feet away from the aircraft where they were disassembled to get at the paper. All the operations, with the exception of actually taking the filter papers out of the holders and putting them into a lead sampler container, were done by hand and personnel who handled these boxes wore cotton gloves. Tongs were used to actually get the filter papers off the holders and into the containers.[55]

Some Special Problems. During Operation SANDSTONE, radiochemical experiments with drones held a high priority. However, the "beeper" pilots aboard the B-17 control aircraft had to have light to properly place these samplers in the cloud. On the other hand, a minimum of light was necessary at the moment of detonation to accommodate yet another important scientific experiment and compromise was needed.[56] While still at Eglin Air Force Base, the drone unit began flying missions to determine more precise light changes at altitude and at ground level, just as dawn approached.[57]

After arrival to the islands, the drone unit began flying missions just before dawn. They experimented with various times and altitudes over target area, and checked light conditions which were also being observed on the surface. On 22 March 1948, General Kepner flew over the area on one of these missions with Colonel Kilgore, and it was decided detonation times for SANDSTONE could be determined. The drone aircraft unit had discovered that, at altitudes over the target area, it was daylight some ten minutes before it was light on the surface. Therefore, the lighting problem was solved by exploding the device some ten minutes before daylight arrived at the water surface.[58]

Another problem was settled during the training program. From which island, in the test area, should the drones operate? The ideal plan would have been to operate the entire unit from Eniwetok because this island was near the target area. However, Eniwetok was a small island and already overcrowded with essential operational units. The first proposal placed drone operations on Kwajalein. For a sampling mission they would be launched, flown to the atomic cloud, then landed on Eniwetok where the Atomic Energy Commission personnel could remove the samples.[59] As a drawback to this proposal, the Pacific area was subjected to frequent rain squalls. During the two and one-half hour flight from Kwajalein to the target area, rain would be hard on the filter papers in the boxes on the fuselage, and probably would rip the papers up. After arriving in the islands the drone unit altered this procedure. On the day before a scheduled shot, pilots would fly the drone aircraft manually to Eniwetok and land them. The ground controllers would go to the island also. On shot morning, the control aircraft would take off from Kwajalein and fly to Eniwetok. The ground controllers would launch the B-17 drone samplers and the control aircraft took them over. After the samples were collected, the control aircraft returned the drones to Eniwetok where they landed and the control aircraft proceeded to Kwajalein. This new plan added 41 additional personnel to the population on Eniwetok, but was considered worthwhile because of the added ability of the drones to secure satisfactory samples.[60] To establish a routine, Task Unit 7.4.2 accomplished many early morning drone flights, simulating missions.

X RAY Shot. The day before X RAY, on 14 April 1948, eight drones were flown from Kwajalein to Eniwetok. On the way, pilots made final electronics checkouts. Before daylight the next morning the control aircraft from Kwajalein arrived overhead and the drones were launched and given over to the control aircraft. At 0550, about half an hour before the shot, the drone unit reported to General Kepner that they were on station.[61] Four were north of the target and four south of it, at 4,000-foot intervals on each side, starting at 14,000 feet and going up to 28,000 feet. When they went into the cloud a sample would be taken from 2,000-foot altitude intervals. The drones were scheduled to make three passes through the cloud before going home.[62]

Just two minutes before detonation, the B-17 drone aircraft flying south of the target at 14,000 feet altitude, suddenly went out of control, and though the control B-17 attempted chase, the drone crashed and exploded in the ocean near Engebi Island.[63]

The shot detonated on schedule and the atomic cloud began to climb. The "beeper" pilots turned their drones off station, aimed them at the cloud, set them on automatic pilot, and turned them loose, then the control aircraft raced around the cloud to retrieve the drones on the other side. Similar to Operation CROSSROADS, this time, however, the control aircraft turned their drones around again aimed at the cloud. On the third penetration, five of the seven drones made contact with the cloud, but the drones at 18,000 and 20,000 feet did not penetrate because the "beeper" pilots could not locate any portion of the cloud at their altitude.

The seven drones landed safely at Eniwetok, where the Atomic Energy Commission crews removed the samples and started for Los Alamos Scientific Laboratory. Preliminary investigation indicated that the weakest sample collected on X RAY was stronger than any taken during Operation CROSSROADS.[64]

YOKE Shot. YOKE Shot was detonated on 1 May 1948. Drone operations were a repetition of X RAY with the exception of a drone flying at 20,000 feet altitude. After arriving on station, the B-17 drone at 20,000 feet was pulled out of its position and sent to 30,000 feet altitude, directly over the detonation. A camera in the drone exposed a picture just at detonation. When the shock wave hit the drone, it was not damaged, but the "beeper" pilot had some moments of control difficulty. Colonel Kilgore recommended to the air commander that this drone be withdrawn from sampling. The other seven drones collected their samples on three passes and returned to Eniwetok. These samples were even better than the ones collected previously.[65]

ZEBRA Shot. ZEBRA day operations were not different from other operations, with the exception that on the last SANDSTONE shot all eight drone aircraft gathered samples. Los Alamos personnel declared the ZEBRA samples to be the best yet.[66]

Rad-Safe Program on SANDSTONE. The Rad-Safe program on SANDSTONE became very important. The unit monitored all aircraft, including the drones, and had Rad-Safe monitors aboard all flights. Participating officers included Lieutenant Colonel Karl H. Houghton, involved in radiation studies at the Air Force Special Weapons Center; Colonel Robert N. Isbell, later to become chief of the Nuclear Applications Branch at Air Research and Development Command; and Colonel J. J. Cody, Jr., Assistant Rad-Safe Chief.[67] From the standpoint of future cloud sampling operations, Colonel Cody's experiments with film badges on the B-17 drone samplers were most significant. He placed these detectors on the outside fuselage of the drones, and inside where crew members would have been had the planes been manned. DELETED

DELETED

During Operation SANDSTONE, an aircraft accidently flew through an atomic cloud and the crew suffered no ill effects. This incident commenced a chain of events which eventually resulted in manned samplers.

As Task Force SEVEN was being staffed, Colonel Benjamin G. Holzman reported as meteorologist. He had served in the same capacity during Operation CROSSROADS.[69] Another of the officers called in to help with the weather missions was Lieutenant Colonel Paul H. Fackler, who was then stationed on Guam.

PRIVACY ACT PROTECTED

MATERIAL REMOVED

I

PRIVACY ACT PROTECTED

MATERIAL REMOVED

Following the mission, Colonel Fackler discussed the experiment with Colonel Cody, assistant rad-safe officer for the operation. This incident, plus the film badge experiments he had conducted, gave Colonel Cody the idea that manned sampler aircraft, operating several hours after a nuclear detonation, might possibly obtain samples much more efficiently than measures used heretofore. With drones, the "beeper" pilot aimed the aircraft toward the atomic cloud and the sample was obtained by pot-luck. A manned sampler could be maneuvered while approaching the cloud, and during penetration so that the most likely parts of the cloud could be sampled. In this way a greater precision in sample size and location was rendered, allowing study of fractionation in greater detail among various portions of the cloud.

Following Operation SANDSTONE, Colonel Cody continued to consider the possibilities of manned sampling. Colonel Fackler meantime, returned to his Air Weather Service duties on Guam.[70]

Operation SANDSTONE Conclusions

In spite of the manned sampling incident, the Air Force concluded from Operation SANDSTONE that the reliability of drone aircraft for collecting cloud samples had been proven, but more drones would be needed for the next test. Sampling required improved drones and improved control equipment. Also, more up to date sampling boxes should be designed for sampler aircraft. One of the biggest arguments for changing the design of the filter collectors was that four Los Alamos personnel suffered serious beta burns on their hands while handling samples.[71] After Operation SANDSTONE, the Air Force recommended that a permanent drone aircraft unit be established to carry out the sampling missions during nuclear tests. Such an organization would allow the retention of experienced personnel and help insure the development of equipment needed for sampling operations.[72]

CHAPTER I

NOTES

1. William Leonard Laurence, Dawn Over Zero: The Story of the Atomic Bomb, (New York, 1950), 188.

2. MSgt. Max Gerster, The Special Weapons Center and Atomic Testing, AFSWC Hist. Div., Jan. 1957, 8.

3. Laurence, Dawn Over Zero, 191

4. Ibid., 191-192.

5. LASL Rpt., TRINITY, Vol. 24, App. 55 thru 71, 9 Oct. 1947; App. 56, p. 4, in Tech. Info. & Intel. Lib.

6. Ibid.

7. Laurence, Dawn Over Zero, 191-192.

8. Gerster, The Special Weapons Center and Atomic Testing, 4.

9. Laurence, Dawn Over Zero, 27, 195.

10. Wesley Frank Craven and James Lea Cate, eds., The Pacific: Matterhorn to Nagasaki, Vol. V, of The Army Air Forces in World War II, (Chicago, 1953), 712.

11. William A. Shurcliff, Bombs At Bikini, (New York, 1947), 10-11.

12. Ibid., 12, 31.

13. Gerster, The Special Weapons Center in Atomic Testing, 10-11.

14. Shurcliff, Bombs At Bikini, 29.

15. Ibid., 98.

16. "Report on Atomic Bomb Tests ABLE and BAKER (Operation CROSSROADS)," prep. by Cmdr., Joint Task Force ONE, Vol. I, 1 July 1946-25 July 1946, Sec. VII-(E)-20, in Tech. Info & Intel. Lib.

17. Ibid., Sec. VII-(E)-19-21

18. William Rubinson, LASL, "Nuclear Efficiencies of the Bikini Shots as Determined by the Radiochemical Method," CROSSROADS Technical Instrumentation Report, Tests A and B, 25 Nov. 1946, 8-10, in Tech. Info. & Intel. Lib.

19. "Report on Tests ABLE and BAKER," Sec. VII-(E)-21, 69.

20. Ibid., Sec. VII-(E)-74.

21. Rubinson, "Nuclear Efficiencies of the Bikini Shots as Determined by Radiochemical Methods," 8-9.

22. "Report on Test ABLE and BAKER," Sec. VII-(E)-74.

23. Ibid., Sec. VII-(E)-107.

24. Ibid., Sec. VII-(E)-74-75.

25. Ibid., Sec. VII-(E)-3, 129-130.

26. Ibid., Sec. VII-(E)-108-109.

27. Ibid., Sec. VII-(E)-110-112.

28. Ibid., Sec. VII-(E)-4.

29. Ibid., Sec. VII-(E)-132-135, passim.

30. Ibid., Sec. VII-(E)-5, 199-200.

31. Ibid., Sec. VII-(E)-199-200.

32. Ibid., Sec. VII-(E)-202-203.

33. Ibid.

34. Ibid.

35. Ibid.

36. Ibid., Sec. VII-(C)-19.

37. Ibid., Sec. VII-(E)-24.

38. Ibid., Sec. VII-(E)-122.

39. Ibid., Sec. VII-(E)-187-188.

40. Ibid., Sec. VII-(C)-19.

41. Rubinson, "Nuclear Efficiencies of the Bikini Shots as Determined by Radiochemical Methods," 25, 27.

42. Ibid., 9

43. Ibid.

44. Ibid., 53.

45. Gerster, The Air Force Special Weapons Center in Atomic Testing, 34-35.

46. Rpt., "Operation SANDSTONE, 1948, Report to the Joint Chiefs of Staff, 16 June 1948," prep. by Lt. Gen. J. E. Hull, USA, Cmdr., JTF 7, Vol. I, 5, 127, in Tech. Info. & Intel. Lib.

47. Gerster, The Air Force Special Weapons Center in Atomic Testing, 34-35.

48. Rpt., "Operation SANDSTONE, Report to the Joint Chiefs of Staff, 16 June 1948," Vol. I, Annex 1, Pt. 2, 23.

49. "Operation SANDSTONE, Report to the Joint Chiefs of Staff",Vol. I, Pt. 2, 3-5.

50. Gerster, The Air Force Special Weapons Center in Atomic Testing, 35.

51. "Operation SANDSTONE, Report to the Joint Chief of Staff," Vol. I, Pt. 2, 56-57.

52. Ibid., 54.

53. Ibid., 53-54.

54. Ibid., 24.

55. Ibid., Vol. I, Annex I, Pt. 2, 13-14, 127; Rpt., "Operation SANDSTONE, Scientific Director's Report of Atomic Weapons Tests," No. 10, Annex I, (Radiochemical Efficiency Results of SANDSTONE Tests), prep. by R. W. Spence and M. G. Bowman, March 25, 1949, 35-36, in Tech. Info. & Intel. Lib.

56. Ibid.

57. "Operation SANDSTONE, Report to the Joint Chiefs of Staff," I, 19-20.

58. Ibid., 41-42.

59. Ibid.

60. Ibid., 44.

61. "Operation SANDSTONE, Report to the Joint Chiefs of Staff," Vol. I, Annex I, Pt. 2, 63-64.

62. Ibid., 12; "Operation SANDSTONE, Scientific Director's Report of Atomic Weapons Tests," Annex 5, Pt. 4, (Air Filters and Airplane Shock Wave Measurements), No. 23, prep. by Col. T. L. Bryan, USAF, 31-49, in Tech. Info. & Intel. Lib.

63. "Operation SANDSTONE, Report to the Joint Chiefs of Staff," Vol. I, Annex I, Pt. 2, 65-66.

64. Ibid., 66-68.

65. Ibid., 71-73; "Operation SANDSTONE, Scientific Director's Report," Annex 6, Pt. 4, No. 23, 59-61.

66. "Operation SANDSTONE, Report to the Joint Chiefs of Staff," Vol. I, Annex I, Pt. 2, 73-75.

67. Ibid., Sec. IV, 1-4; "Operation SANDSTONE, Scientific Director's Report of Atomic Weapons Tests," Annex IX, Pt. III, No. 30, 1, 11, 13-14, 18-21.

68. Ibid.

69. "Operation SANDSTONE, Report to the Joint Chiefs of Staff," Vol. I, Annex I, Pt. 2, 29.

70. Interview with Col. P. H. Fackler, AFOAT-1, 24 July 1957, see App.

71. "Operation SANDSTONE, Report to the Joint Chiefs of Staff," Vol. I, Annex I, Pt. 2, 97-98; "Operation SANDSTONE, Scientific Director's Report," No. 10, 56-57.

72. "Operation SANDSTONE, Scientific Director's Report," Annex 5, Pt. 4, No. 23, 26.

CHAPTER II

EARLY MANNED SAMPLING ACTIVITIES

Following Operation SANDSTONE there were three years during which no nuclear testing was attempted by the United States. However, the Atomic Energy Commission continued research and laboratory experiments on nuclear weapon design and determined more testing would be needed. One of the drawbacks to nuclear testing was the high cost of operating in the Pacific. The Atomic Energy Commission, therefore, suggested that a location within the United States be used for smaller nuclear detonations. Several sites were considered but no action taken.

Sampling Operation RANGER

Meanwhile, time approached for another test series. This was Operation GREENHOUSE, scheduled for the Pacific Proving Grounds in 1951. However, there were a number of minor weapon design problems which needed solving beforehand, and in November 1950, the Atomic Energy Commission resurrected its proposal for a continental testing site. In December, approval was given to use the Las Vegas Bombing Range, northwest of Las Vegas, Nevada. The Atomic Energy Commission also proposed that the testing site be put to use immediately to secure the information needed for GREENHOUSE. This proposal was sent to the President who approved it on 11 January 1951, and Operation RANGER followed. From the first proposal to the final shot the entire operation was planned and executed in less than three months. Though "quick and dirty," Operation RANGER contained a good many "firsts" in atomic testing. It was the first nuclear detonation in the United States since the TRINITY; contained the first airdrop of a nuclear device within the United States; saw the first burst photographic effort, using radarscope images; and, perhaps most significant of all, the first attempt to sample a nuclear cloud with a manned aircraft.[1]

Manned Sampling. Following Operation SANDSTONE, Colonel Joseph J. Cody, Jr., had continued work on the possibilities of collecting cloud samples with manned aircraft. For three years, he conducted, or had conducted, a number of theoretical studies which were favorable, but realized there was no time to organize drone samplers for this operation. However, he asked the Air Weather Service headquarters for some WB-29 aircraft with which to conduct experimental sampling. The request came just 28 days before the first shot was to be fired and Colonel Fackler, who had been transferred from Guam to Washington since SANDSTONE ended, helped secure these aircraft.[2] Eventually three WB-29 aircraft were removed from storage and made ready for the sampling program. Personnel installed filter boxes, like the ones used on drone aircraft during SANDSTONE.[3] Two more WB-29 aircraft were secured and modified to track the cloud.

Several purposes evolved for the program. First the cloud tracking aircraft were a requirement established by the Atomic Energy Commission. The cloud samplers, however, were for the Air Force atomic energy detection system. They also afforded an opportunity to calibrate radiac instruments then available, and to test the feasibility of manned

Colonel Paul H. Fackler

sampling collecting from a nuclear cloud several hours after an atomic detonation.[4]

On 21 January 1951, Colonel Fackler with a Major Lester R. Ferriss, Jr., flew to Nellis Air Force Base in order to establish an aircraft control facility where communications were available and where they plotted positions of the cloud sampler and cloud tracker aircraft. They established a control center separate and independent of the center maintained for all other aircraft in the test. The two colonels alternated as aircraft controller. They were followed by the WB-29 aircraft and crews on 24 January 1951, and early the next morning, they took off to participate in the full-scale rehearsal.[5]

On the morning of 27 January 1951, the B-50 aircraft carrying the first nuclear device for Operation RANGER arrived over the test site, having taken off from Kirtland Air Force Base. At 0245, the first sampler, QUEBALL One, took off from Nellis Air Force Base.

PRIVACY ACT PROTECTED

MATERIAL REMOVED

PRIVACY ACT PROTECTED

MATERIAL REMOVED

The latter method prevailed for the remainder of Operation RANGER. During the second shot, fired on 28 January 1951, only one aircraft gathered samples. On the third shot, 1 February 1951, two samplers operated; on 2 February 1951, only one aircraft sampled. For the last shot, on 6 February, two aircraft sampled.[7]

During Operation RANGER, Major General Roscoe E. Wilson, from the Office of the Assistant for Atomic Energy, visited the site and Colonel Cody and Colonel Fackler gave a description of their manned sampling activities. Although the program had been conducted for the benefit of AFOAT-1 programs, they argued that manned aircraft could be used instead of drones to gather cloud samples for the Atomic Energy Commission radiochemical program. General Wilson agreed that the idea sounded good and suggested that Colonel Fackler draw up more definite plans if the results of the RANGER experiments were successful.[8]

Preliminary reports indicated that the samples were strong enough for laboratory experimentation, even though they were gathered long after detonation. Also, Colonel Cody reported: "The indicated exposure levels of the crews in these operations have been below those anticipated in the initial calculations." He advised that, if the Air Force planned to use manned samplers on future operations, more adequate instruments and equipment be developed. And, finally, ". . . it may be wise for the Air Force, if such operations are to be continued, that a test unit be formed to do this type of operation."[9]

Operation GREENHOUSE

Within a few months of the ending of Operation SANDSTONE, plans were under way for another nuclear test series in the Pacific in 1951. By mid-December 1948, the Los Alamos Scientific Laboratory established requirements for at least eight drone samplers which were to make about two penetrations. On 18 January 1949, Air Materiel Command held a preliminary conference to consider drone requirements, ". . . since it was generally recognized that radiological sampling provided one of the most important methods of measuring weapon efficiency." Plans called for aircraft to penetrate the cloud at relatively slow speeds and it was decided B-17 drone aircraft were to be used. However, a month later some officials considered changing the drone-type aircraft, but development necessary and the time were thought to be excessive. In

May 1949, that Command went ahead with drone aircraft plans. The Atomic Energy Commission needed 12 drones and 12 director B-17 aircraft, while Air Force program required 5 B-17 drones, 3 B-17 directors, 6 TF-80 drones and 5 TF-80 directors.[10]

In August 1949, Major General Carl A. Brandt, Chief of Requirements at Air Force headquarters, confirmed these requirements with instructions to the Air Proving Ground Command to supply this support for the 1951 tests.[11] Requirements changed but slightly. The TF-80 drone and director aircraft were replaced by T-33-type aircraft.[12]

Task Group 3.4, for Operation GREENHOUSE, formed at Eglin Air Force Base, Florida, under the command of Major General Robert M. Lee. The Task Group was to operate all Air Force experimental aircraft, provide weather reconnaissance and forecasting, inter-atoll air transportation, and operate the airbase facilities on Eniwetok Island.[13] The Experimental Aircraft Unit of the Task Group came under the command of Colonel Thomas J. Gent, who also commanded the 550th Guided Missiles Wing of the Air Proving Ground. Called Task Unit 3.4.2, it was unique in that it consisted of regular Air Force organizations redesignated for task group missions. The 550th Guided Missiles Wing operated the drone aircraft for GREENHOUSE, while its 3200th Drone Squadron provided the electronics section for the operation. "The majority of these individuals had participated in former atomic weapons tests where drone aircraft were employed," the Task Group final report stated. "Their experience was an invaluable guide in organization of this Task Unit and in training personnel."[14] At Eglin, personnel worked out drone operations and, later, training of the unit at Eniwetok continued until the GREENHOUSE shots were scheduled.

Drones at GREENHOUSE. The first shot fired on the morning of 8 April 1951. Before DOG Shot, Colonel Gent's drone unit launched a good many aircraft. The two T-33 drones, with their control aircraft, were scheduled to take blast and gust measurements. The first drone went out of control on takeoff and crashed. The second T-33 scraped a wingtip on takeoff but continued on and completed its mission. One of two B-17 drone aircraft also scheduled to take blast measurements, aborted because it did not respond to controls.[15]

The fleet of aircraft presented a large array. There were 20 B-17 aircraft in the vicinity of the detonation to secure samples. Eight of these were drones, 8 were directors, and the remaining 4 were master control aircraft. The drones were stacked at 2,000-foot intervals from 16,000 to 30,000 feet. Sampling went as scheduled, excepting for the drone at 26,000 feet altitude which suddenly stopped responding to signals from its control aircraft. By the time the master aircraft regained control, there was no time to guide it through the cloud. With this exception, all the drones took good samples.[16]

EASY Shot followed on 21 April 1951. On this occasion both T-33 drones were lost. One received heavy damage from the shock wave, lost control, and crashed; the second was not so badly damaged but refused to respond to control signals. It crash landed on deserted Bogallua Island and exploded; however, personnel removed usable magnetic tape data from the wreckage. The B-17 sampler drones carried out their mission without incident.[17]

The third shot was GEORGE, fired on 9 May 1951. Wet weather before the shot caused drone crews to use heaters and fans in order to dry out electronic equipment. During operations, one of the B-17 drones did not respond correctly to directions and was returned to base. The other seven drones completed sampling missions.

During the final shot, ITEM, on 25 May 1951, one of the B-17 drones did not respond. To each signal, the drone reduced power. While both the control and master control aircraft tried to remedy the situation, the drone finally stalled and dived into the ocean. The other seven aircraft performed adequately.[18]

The two WB-29 aircraft of the Air Weather Service which collected samples received little attention. Except during the first GREENHOUSE event when one of the WB-29 aircraft aborted because of engine trouble, the two manned samplers participated in each shot.[19] After Operation RANGER there had been little or no time but Colonel Fackler and Colonel Cody obtained two aircraft from Air Weather Service. They operated from Kwajalein and were considered a minor part of the test aircraft pattern around the nuclear blasts. The two repeated their experiences of Operation RANGER, with the exception that the crew radiation dosages were a bit higher.[20]

Operation BUSTER/JANGLE

Following Operation GREENHOUSE, the Air Force and the Atomic Energy Commission looked more favorably upon manned samplers. GREENHOUSE became the last atomic test series during which drone aircraft were used for this purpose. At Air Weather Service headquarters in Washington, Colonel Fackler worked out what he considered to be a reasonable test unit for the Air Force portion of atomic testing. The plan called for C-82 transport aircraft, helicopters, radio jeeps, B-29 sampler aircraft, aircraft to track atomic clouds and for terrain surveys, and those required for logistic and administrative support.* Major General Wilson, Office of the Assistant for Atomic Energy, agreed that such an organization would be good for atomic energy testing; but, the services were operating under short funds and the Korean War was in progress. General Wilson believed the plan was too "plush" and would never be approved by the Air Force. However, Brigadier General John S. Mills, Commander, Special Weapons Command, was looking for men and the General asked if Colonel Fackler would like to transfer there, so that he became part of the mainstream of sampling activities.[21]

Meanwhile, on 7 May 1951, a group of officers from Special Weapons Command visited the Los Alamos Scientific Laboratory and were told that a new test series was planned for the fall, and that the Command would

*This organization would have been comparable to the 4950th Test Group (Nuclear) which was finally organized five years later.

be the coordinating agency for all Air Force participation. Later, in July 1951, the Command was made coordinating agency for all military participation in the test series, except for ground forces which would hold maneuvers around the test area.[22] On 17 May 1951, Brigadier General Mills visited Air Force headquarters after observing Operation GREENHOUSE tests. There he was asked to provide cloud sampling and tracking, and the terrain survey flights for a new continental series. He assured the Washington officials that his command could perform these duties.[23]

Preparation for Sampling BUSTER/JANGLE. In July 1951, Lieutenant Colonel Karl H. Houghton, with Lieutenant Colonel Earl W. Kesling, the Special Projects Officer for Operation BUSTER/JANGLE, visited Los Alamos Scientific Laboratory for discussions with Dr. Alvin C. Graves, Test Director.* They believed the use of jet aircraft for sampling worth trying. Dr. Graves agreed to the use of jet sampler aircraft on an experimental basis.[24] The result was the most extensive aircraft inventory yet asked for nuclear testing. The Special Weapons Command's 4925th Test Group (Atomic) was responsible for supplying these aircraft but did not have enough to cover the requirements. On 28 and 29 July 1951, the 4925th sent two of its B-29 aircraft to McClellan Air Force Base, California, for modifications. In accordance with AFOAT-1 requirements, airfoil sampling equipment was installed in the aft unpressurized

*Lieutenant Colonel Houghton, Special Weapons Command Air Surgeon, was appointed the Radiological Safety Coordinator for the Command.

compartment, above the fuselage. Air Materiel Command supplied a third modified B-29. These three were flown to Kirtland Air Force Base in August 1951 but they had hardly arrived when the Atomic Energy Commission desired additional wing box filters to be installed by the maintenance crews of the 4925th.[25] On the other hand, the Air Proving Ground Command supplied jet aircraft for the sampling. Three T-33 aircraft, plus pilots, radiological officers, and maintenance personnel comprised the Eglin group, under the command of Captain Edwin R. Kregloh.[26]

The Los Alamos Scientific Laboratory designed, supplied, and owned the sampling equipment for manned sampling. With the exception of AFOAT equipment used for long-range, low-level sampling, this included outfitting the T-33, F-84, B-36, and the current B-57 equipment. The Laboratory's contractors were Professor Elliott Reid from Stanford University on aerodynamics; Tracerlab for design and construction on the T-33, F-84, and B-36 aircraft; and the Glenn L. Martin, Solar Aircraft, and Century Engineers furnished the equipment on the B-57. They were built into the fuel tanks, but there was not enough time to rework the T-33 aircraft so the tanks could also carry fuel. Therefore, during Operation BUSTER/JANGLE the T-33 samplers had very limited range.[27] But, by October 1951, the six sampler aircraft were ready and, on 10 October 1951, three B-29 and three T-33 aircraft moved to Indian Springs Air Force Base.

The 4925th Test Group (Atomic) borrowed further. Three B-29 weather aircraft came from the 57th Reconnaissance Squadron, at Hickam

Air Force Base, Hawaii, and operated from Kirtland. Major Roy E. Ladd, who had commanded the first manned sampler during Operation RANGER, was the commanding officer.[28]

<u>The BUSTER/JANGLE Shots</u>. The 4925th Test Group (Atomic) had operational control over all aircraft in the test patterns. These included two B-50 indirect bomb damage assessment aircraft, one B-29 on the same mission, three C-47 photographic aircraft, one C-54 flash blindness aircraft, two B-29 paradrop aircraft, one P2V and one B-17 radiac aircraft, one C-47 disaster aircraft, the bomb carrier, and, finally three T-33 and three B-29 samplers.[29] Lieutenant Colonel Fackler and Major Travis M. Scott were in charge of the air plotting room which pin-pointed the positions of the samplers, trackers, and terrain survey aircraft.[30] This function took place in the control point building, then in the process of being built at the Nevada Proving Grounds. There was no electronics equipment installed and radar was not available. Nevertheless, they secured three large sheets of plexiglas, edge-lighted them, and supplied the six plotters with colored pencils. One board plotted the progress of the aircraft flying from Kirtland Air Force Base; the second contained the plots of the aircraft in the vicinity of the test site, in their orbits; and a final board formed a plot of the test site itself and had room to plot the course of the cloud trackers and the terrain survey aircraft. The activity in this control room began near midnight, continued through

detonation of the test shot, and continued until about dark when the cloud tracker aircraft returned.[31]

BUSTER ABLE. Scheduled for the morning of 19 October 1951, the first shot was postponed. Test aircraft were in the air; however, the firing mechanism did not operate properly and the shot failed to detonate. The Atomic Energy Commission was successful with the device on the morning of 22 October 1951. The shot produced very little nuclear radiation and terrain survey and cloud tracker aircraft were cancelled, and one of the B-29 samplers went home.[32]

For ABLE Shot the B-29 samplers operated from Nellis Air Force Base, near Las Vegas, because Indian Springs had no night lighting facilities. The B-29 samplers carried on all flights a radiological officer and a trainee radiological officer, in addition to the regular crew. Each airplane collected data for both the AFOAT-1 organization and for the Atomic Energy Commission. Because of the low yield of the first shot, the B-29 which did not sample had a rather long mission. The first pass through the cloud resulted in no radiation being detected. Therefore, the sampler made eight more passes through the cloud at altitudes from 100 feet to 7,500 feet which finally resulted in adequate samples.[33] It flew directly to Indian Springs Air Force Base, landed, and taxied to the decontamination area where the crew left the aircraft through the nose wheel door and were carefully monitored for contamination. Dr. Harold F. Plank, Los Alamos Scientific Laboratory radiation expert, with a crew of technicians from the laboratory, then went about removing the paper samples from the aircraft and preparing them for

Airmen monitor B-29 sampler during decontamination procedures, Operation BUSTER/JANGLE shipment to the various laboratories involved. An AFOAT-1 crew aided in this work during the entire operation and Colonel Houghton's radiological safety personnel were on hand to gain experience in monitoring and sample paper removal.[34]

BUSTER BAKER. The second shot of the series was an airdrop. On 26 October 1951, the drop aircraft arrived over Las Vegas, Nevada, from Kirtland, but returned when the weather did not clear. Two days later the drop occurred. Two B-29 samplers were in orbit and obtained good samples. The first of the T-33 jet samplers took part with a pilot and a radiological officer aboard. There were filter holders on the wingtips of the aircraft. Upon orders from Colonel Fackler's operation center at the control point, it took off from Indian Springs and made a spiral climb to the required altitude for sampling passes. The aircraft was depressurized and both crew members went on 100 per cent oxygen. After securing the samples, the T-33 returned to Indian Springs, where the process in the decontamination area was similar to that for B-29 samplers.

This first experience with the T-33 aircraft indicated that some method of vectoring the aircraft to the cloud was needed because, without the fuel ordinarily carried in wingtip fuel tanks, the aircraft had a limited range of only one hour and five minutes. As a possible solution, Colonel Fackler had the B-29 aircraft give five minute position reports on the cloud thereafter.[35]

BUSTER CHARLIE. The third event occurred on 30 October 1951, when a Kirtland plane dropped another device over the Nevada Test Site. Two B-29 aircraft and two T-33 aircraft collected samples. The third B-29 sampler collected samples from the cloud five hours after detonation.

Control of the T-33 samplers was still unsatisfactory. The aircraft controllers set up a grid map so the B-29 samplers could give more accurate cloud positions. Control was further complicated, however, by not having electronics equipment at the control point, and Colonel Fackler observed the sampler aircraft through field glasses. At this point, it was decided the radiological officers should have more control over the aircraft as another possible solution.[36]

BUSTER DOG. The DOG Shot was dropped on 1 November 1951. The cloud retained its "puff" configuration for a long time and four samplers had little trouble with their missions.[37]

BUSTER EASY. A Kirtland aircraft dropped EASY on 6 November 1951, and the largest array of the operation gathered data from the shot. Both B-29 samplers suffered difficulties. The first had engine trouble and was unable to climb above 31,000 feet and returned with a poor sample. The second B-29 aircraft made one pass through the cloud and the radiological officer reported the crew had been exposed to an extremely high radiation dosage. After he repeated the reading with the same results, the radiological officer at the control point ordered the aircraft to return to base immediately. On the ground, it was discovered that he had misread the instruments. Both the T-33 jet samplers collected excellent samples. One experiment allowed the aircraft to be pressurized during the cloud penetration. Filtering systems in the air intakes effectively excluded contamination.[38] At the close of these missions, the T-33 samplers returned to Eglin Air Force Base.

JANGLE SUGAR. Because of weather conditions, the JANGLE surface test was postponed on the 15th, then the 16th, 17th, and 18th of November 1951. Finally, on 19 November 1951, the shot fired but since the cloud was not expected to rise very high, only two B-29 samplers were scheduled. One aircraft operated at about 13,000 feet, while the other sampled the dust cloud between 1,000 to 2,000 feet altitude. On the first sampling pass at the lower cloud, the B-29 flew at 2,000 feet and got a reading reflected from the bomb crater. Seven minutes later the aircraft made another pass at 1,000 feet altitude, some five miles from the crater to be certain of a good sample. The samples from both B-29 aircraft were adequate.[39]

JANGLE UNCLE. The underground shot, last of the test series, occurred on 29 November 1951 and the sampling plan was the same as for the surface shot. The cloud rose initially to about 11,000 feet but drifted down to about 9,500 feet. The B-29 sampling the upper cloud made seven penetrations to be sure of a usable sample, but the cloud moved around mountain peaks which complicated results. Meantime, the B-29 taking samples from the dust cloud made four penetrations before a usable sample was obtained.[40]

Evaluating Jet Samplers

The B-29 bomber had a number of disadvantages as samplers. First, the big aircraft required a larger crew, which resulted in a larger number of people exposed to radiation during a mission. The T-33 jet aircraft, on the other hand, exposed only two individuals. Furthermore, the B-29 bomber was slow, subject to extended radiation while it went through the cloud. The T-33 jet was much faster, performing its mission more efficiently. The T-33 being a smaller aircraft, gathered radiological contaminations over a smaller area of surface than the B-29. Finally, the jet aircraft returned to the ground station faster after leaving the cloud. When comparing the results of these missions, officials found that the T-33 samples were far better than the B-29 and six times as strong in many instances.[41]

Colonel Fackler's final report of air participation concluded with the recommendation that either F-89 or F-94 aircraft replace the T-33. The latter, while presenting a number of advantages over bomber aircraft, did not have the altitude capabilities desired for sampling. In addition, the report recommended that sampler aircraft be assigned to the Special Weapons Command permanently in order to facilitate installation of instruments.[42]

Operation TUMBLER/SNAPPER

Within a few days the Special Weapons Command received word that another continental test program would be conducted at the Nevada Test Site in the spring of 1952. Both the Atomic Energy Commission and the

Department of Defense had test data questions to be answered before the fall of 1952 overseas Operation IVY. The new series was called Operation TUMBLER/SNAPPER with TUMBLER tests supplying weapons effects information to the Department of Defense, while the SNAPPER tests would answer weapon design questions for the Los Alamos Scientific Laboratory.[43] Lieutenant Colonel Kesling was again in charge of planning. In January 1952, Colonel Osmund J. Ritland, commanding officer of the 4925th Test Group (Atomic), appointed Lieutenant Colonel Fackler the special projects officer. Colonel Fackler, therefore, had the duty of drawing up the Group's operational plan for TUMBLER/SNAPPER. He also headed the Test Aircraft Unit for the tests, and served as the air operations officer. Assisting Colonel Fackler at the control point were Captain Dominic F. Menza and Master Sergeant Jerome H. Day, both of the 4925th Test Group (Atomic).[44]

During previous operations the Special Weapons Command had jurisdiction of all military participation in continental testing. During planning TUMBLER/SNAPPER, the Department of Defense assigned to the Armed Forces Special Weapons Project this function and the Special Weapons Command was made responsible for Air Force participation.[45]

Aircraft and Aircrews for Sampling. Personnel from the Los Alamos Scientific Laboratory approved of the sampling accomplished by T-33 aircraft. In December 1951, Dr. Graves wrote General Mills asking that jet aircraft be used for all future sampling missions in Nevada. At the same time, however, Dr. Graves suggested aircraft with more altitude performance, such as the F-94C or the F-89C. To be absolutely safe, the aircraft should carry no less than two men. Since six jet aircraft were needed this time Dr. Graves believed they should be assigned to the Special Weapons Command because of the necessity of modifying airplanes for sampling and the need for training crews. At the same time, he agreed with Colonel Fackler that control of sampling aircraft should be accomplished from an airborne control center and for this purpose, he suggested a B-50D.[46]

Pursuing these views, Dr. Harold F. Plank, the Los Alamos cloud sampling expert, visited Colonel Clyde Box, Deputy Chief of Staff for Operations at the Special Weapons Command, to discuss possible aircraft. Colonel Box recommended the F-94C aircraft since it carried two men, had an excellent altitude capacity, good range, and could use the wing filter tanks developed by the Los Alamos Scientific Laboratory.[47] Sometime in mid-January 1952, therefore, Colonel Daniel E. Hooks, Chief of Staff of the Special Weapons Command, prevailed upon Air Force headquarters for F-94C samplers. Two men were essential for sampling aircraft, he explained, one man to fly the aircraft and the other to monitor the radiological instruments. He pointed out the undesirable aspects of borrowing aircraft for each nuclear test series, modifying them, and training crews. Colonel Hooks wrote:

> The present plans call for from three to four continental tests per year which will involve the use of the aircraft in actual cloud sampling missions for approximately one and one-half months during each test, or from four and one-half to six months per year. This does not allow for any preparation time. The essential training and refinement of new equipment and procedures will keep the aircraft fully employed between tests.

The colonel concluded with a request that six F-94C aircraft, less radar equipment, be assigned permanently to the Special Weapons Command as soon as possible. If F-94C aircraft could not be procured in time for Operation TUMBLER/SNAPPER, he asked that six T-33 aircraft be assigned temporarily.[48]

At the same time, Dr. Graves wrote the Atomic Energy Commission asking for intercession with the Chief of Staff for the Air Force in favor of the request for F-94C aircraft.[49] The military representatives on the Commission staff passed the request on to Brigadier General Howard G. Bunker, Assistant for Atomic Energy at Air Force headquarters, pointing out the urgent need.[50] Late in January 1952, however, the Special Weapons Command staff was told that no F-94C aircraft were available for sampling and probably would not be available for at least a year. Air Force headquarters planned to borrow T-33 aircraft for Operation TUMBLER/SNAPPER, but in case six T-33 aircraft were not available because of shortage B-29 bombers would be used again to back up the jet samplers.[51] In turn, F-84G aircraft had been approved for sampling during Operation IVY, scheduled for the Pacific Test Site in the fall of 1952. The 4925th Test Group (Atomic) requested that these aircraft be obtained for TUMBLER/SNAPPER, but Air Force headquarters replied there were not enough F-84G aircraft available to support both tests. In the end, Air Proving Ground Command could loan three T-33 aircraft and their crews to the 4925th Test Group (Atomic), and the Air Research and Development Command would supply additional aircrews.

On 3 March 1952, the Air Proving Ground Command sent two T-33 and crews to Kirtland Air Force Base for training and modification. A week later an additional airplane and crew arrived from Eglin Air Force Base, and an airplane and crew from Wright Air Development Center. As these four aircraft were being modified and instrumented for sampling, the crews went to school, conducted by the 4925th.[52] When the lectures on sampling were finished, the crews commenced simulated cloud missions. Some 30 flights were made, using vapor clouds in the Albuquerque area.

In addition to the jet aircraft, one B-29 bomber belonging to the 4925th took samples during TUMBLER/SNAPPER. It was included to conduct an experiment in cabin filtering for sampling aircraft. On former missions, the aircraft crew depressurized the aircraft and went on 100 per cent oxygen just before the first pass at an atomic cloud. The crew then remained on 100 per cent oxygen until the aircraft landed. During TUMBLER/SNAPPER, the B-29 sampling mission was conducted with the aircraft pressurized and without the 100 per cent oxygen and, from all indications, no crew member breathed contaminated air. Minor leaks in the aircraft resulted in some slight contamination to the clothing and skin of the crew, but the mission was more comfortable and with less than normal contamination in the interior of the aircraft.[53]

Control of the samplers underwent a change during TUMBLER/SNAPPER. To avoid the constraints inherent in ground control, for TUMBLER/SNAPPER a sampler control aircraft was employed. This was a B-29 bomber carrying a flight crew, a radiological director, and representatives from both the Los Alamos Scientific Laboratory and the Strategic Air Command. The controller followed the atomic cloud and directed the aircraft into it when the radiological director believed conditions were optimum. Through this method the sampler pilots could be told exactly what portion of the cloud to penetrate. The system worked very well and became a regular technique for future sampling.[54] In all, the Operation TUMBLER/SNAPPER sampling mission involved six aircraft: four T-33 jet samplers, one B-29 sampler, and one B-29 sampler control aircraft. In addition, there were crews which received on-the-job training.

Since the Air Force was scheduled to use F-84G jet aircraft for collecting samples during Operation IVY, the Department of Defense required that sampling techniques with these aircraft be tested during this operation. The Air Force organization for IVY, Task Group 132.4, was being formed at Kirtland Air Force Base and, hence, their sampler aircraft and crews took part in the TUMBLER/SNAPPER. Five F-84G jet aircraft were sent to Kirtland by the Strategic Air Command's 12th Fighter Wing, at Bergstrom Air Force Base, Texas. On 10 March 1952, the first group of 16 officers arrived to begin training for cloud sampling and terrain surveys under the direction of the 4925th Test Group. Altogether, 27 jet pilots received training in radiological safety and fundamentals of cloud sampling. Later, during the shots, the F-84 pilots received experience in sampling clouds after the B-29 and T-33 aircraft completed their missions.[55]

On 26 March 1952, test aircraft and crews, maintenance personnel flew from Kirtland to Indian Springs Air Force Base. On the same day Colonel Fackler set up his air control facilities. The sampler unit established headquarters in a large Quonset hut on the east end of the flight line where the samplers had their briefing room as well.[56]

Besides controlling all test aircraft, Colonel Fackler had yet another function. After the weather briefing, the night before a scheduled shot, Colonel Fackler analyzed the report and advised the test director, Dr. Graves, on expected conditions. If there was to be more than 0.3 cloud cover at the time of the shot, Colonel Fackler announced that jet sampler aircraft would not be permitted to fly. Cloud cover could be a serious matter for if the samplers were some 200 miles from Indian Springs when they completed their cloud penetrations, they would fail to return because of their time and fuel limitations.[57]

Sampling TUMBLER/SNAPPER Clouds. On the morning of 30 March 1952, a Special Weapons Command bomber dropped a "pumpkin" (high explosive bomb) in the dress rehearsal for the tests.* The controller aircraft was on orbit while the B-29 sampler made passes at the cloud and, the four T-33 jet samplers came from Indian Springs for simulated sampling passes. Rehearsals went well and all sampling crews met in the Quonset hut later in the day to discuss last minute changes.[58]

*Two days later, on 1 April 1952, the Command became the Air Force Special Weapons Center, under the Research and Development Command.

The Air Force Special Weapons Center launched a bomb-carrying bombardment aircraft from Kirtland to drop the first shot, ABLE, of TUMBLER/SNAPPER on the morning of 1 April 1952. The sampling missions went off without a hitch. The B-29 controller called up the B-29 sampler, then the four T-33 samplers and each made several passes into the cloud. After their removal by radiological crews, the samples were put into a courier aircraft operated by the 4901st Support Wing (Atomic) and flown back to Kirtland for transfer from there to the Los Alamos Scientific Laboratory.[59]

The BAKER Shot occurred on 15 April 1952. This time the B-29 control aircraft penetrated the cloud because the regular B-29 sampler had returned to base. The cloud scattered in several directions, but good samples were obtained by the control and four T-33 aircraft.[60]

CHARLIE Shot was dropped on 22 April 1952, and sampling progressed as scheduled. One of the T-33 samplers aborted while another T-33 sampler returned to Indian Springs where the papers were removed, new sampling paper installed in the filter tanks, with a new crew it sampled the cloud the second time. During this shot the first of the missions occurred with the Strategic Air Command F-84G pilots. After the T-33 samplers performed their missions, the control aircraft called five F-84G airplanes, one-by-one, up to the cloud for sampling runs.[61]

The last airdropped device, DOG, was detonated on 1 May 1952. Except for some mechanical difficulties encountered by the B-29 sampler, the T-33 and F-84G aircraft operated very well.[62]

The fifth shot, SNAPPER 5, or EASY,* was from a 300-foot tower on 7 May 1952. The wind took the cloud and strung it into a long, thin ribbon, and one concentration of material formed about ten miles behind the leading edge of the cloud. Two of the T-33 aircraft collected adequate samples and returned to Indian Springs. Meanwhile, another T-33 airplane climbed to its assigned altitude and began orbit, waiting for the control aircraft to direct it into the cloud. However, when the order came, this crew could not find the cloud and was forced to return to Indian Springs. The fourth T-33 encountered an oxygen malfunction which forced the pilot to descend. This, in turn, caused his fuel consumption to be higher so that it had to land at Caliente, Nevada. Of the four F-84G aircraft, one had fuel tank trouble and turned back before reaching the cloud; the other three aircraft collected good samples.[63]

SNAPPER 6, or FOX, was a tower shot on 25 May 1952. All the sampling operations progressed smoothly.[64] On 1 June, SNAPPER 7, GEORGE, was fired on a tower with equally good results. For this shot, the F-84G pilots ". . . checked out final manned sampling techniques."[65]

The last shot of the series, SNAPPER 8, or HOW Shot, from a tower on 5 June 1952, proved to be the most difficult to sample. The cloud climbed rapidly and was caught by the wind, moving along at about 60 miles an hour, tearing it into fragments and scattering them. The

*The Air Force used the coded alphabet for these shots, ABLE through GEORGE, but this appears not to be officially accepted in current Department of Defense references.

B-29 control aircraft followed the lower portion of the cloud from which most of the samples were taken. Only one of the T-33 aircraft took what was considered an excellent pass on the cloud, although all made adequate samples. Aside from the scattering of the cloud, another possible reason given for the sampling difficulties was that the sampler control aircraft waited too long before calling up the sampler aircraft.

PRIVACY ACT PROTECTED

MATERIAL REMOVED

Harold F. Plank, Los Alamos Scientific Laboratory, expert on sampling techniques and veteran radiological officer

CHAPTER II

NOTES

1. MSgt. Max Gerster, The Special Weapons Center and Atomic Testing, AFSWC Hist. Div., Jan. 1957, 45-48.

2. Interview with Colonel Paul H. Fackler, AFOAT-1, 24 July 1957, see App.

3. Rpt., "Atomic Energy Detection System Participation in Operation RANGER, 11 June 1951, "prep. by Lt. Col. J. J. Cody, Jr., Ch. Spec. Proj. Br., AFOAT-1, Annex 7, pp. 1-2, in Tech. Info. & Intel. Lib.

4. Memo., to Col. W. B. Reed, AFOAT-1, prep. by Lt. Col. J. J. Cody, Jr., 12 Feb. 1951, subj.: Preliminary Narrative Report on AFOAT-1 Participation in Operation RANGER; interview with Col. Fackler, 24 July 1957.

5. Ibid.; "Atomic Energy Detection System Participation in Operation RANGER," 11 June 1951, (Air Weather Service Participation in Operation RANGER), Annex 7, see App.

6. Rpt., "Operation RANGER, Report on B-29 Cloud Sampler and Cloud Tracker Missions," n.d., n.s., in "Atomic Energy Detection System Participation in Operation RANGER," Annex 7; interview with Col. Fackler, 24 July 1957.

7. Rpt., "Operation RANGER, Report on B-29 Cloud Sampler and Cloud Tracker Missions."

8. Interview with Col. Fackler, 24 July 1957.

9. Memo., Preliminary Narrative Report on AFOAT-1 Participation in Operation RANGER, 12 Feb. 1951, see App.

10. Lt. Gen. Elwood R. Quesada, Cmdr., JTF-3, History of Operation GREENHOUSE, 1948-1951, 12 Dec. 1951, II, 85, in Tech. Info. & Intel. Lib.

11. Ltr., Maj.-Gen. Carl A. Brandt, Ch., Ops. Req. Div., Tng. & Reqs., USAF, to CG, APGC, 8 Aug. 1949, n.s., in Acft. Req. Br., DCS/O Div. files.

12. Memo., to Maj. Gen. R. M. Lee, Cmdr., TG 3.4, prep. by Col. C. A. Thorpe, JTF-3, 27 Feb. 1950, subj.: Status of Task Group 3.4 for week 20 February through 24 February 1950, in DCS/O files.

13. History of Operation GREENHOUSE, I, 23.

14. "Final Report, Task Group 3.4, May 1950-May 1951," prep. by Maj. Gen. R. M. Lee, Cmdr., TG 3.4, n.d., App. C, 131, in Tech. Info. & Intel. Lib.

15. Ibid., 56

16. Ibid.; History of Operation GREENHOUSE, II, 106.

17. "Final Report, Task Group 3.4," 58-59.

18. Ibid., 62-63; History of Operation GREENHOUSE, II, 144.

19. "Final Report, Task Group 3.4," 56, 59, 61, 62-63.

20. Interview with Col. Fackler, 24 July 1957, see App.

21. Ibid.

22. Gerster, Air Force Special Weapons Center Participation in Atomic Testing, 65-68.

23. Lt. Col. J. C. Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 1951, A History, 30 Jan. 1952, 8.

24. Ibid., 38.

25. Rpt., "Technical Air Operations, Operation BUSTER/JANGLE," prep. by Lt. Col. P. H. Fackler, 4925th TG (A), Jan. 1952, 7.

26. Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 61; "Technical Air Operations, Operation BUSTER/JANGLE," 7.

27. "Technical Air Operations, Operation BUSTER/JANGLE," 7.

28. Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 61, 72.

29. Mo. Hist., 4925th TG (A), Sep. 1951, in AFSWC Hist. Div. files.

30. Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 75.

31. Interview with Lt. Col. Travis M. Scott, Res. Rep., ADC, AFSWC, conducted by Warren E. Greene, AFSWC Hist., 14 Aug. 1957.

32. Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 79; "Technical Air Operations, Operation BUSTER/JANGLE," 8, 14-15.

33. "Technical Air Operations, Operation BUSTER/JANGLE," 8, 14-15, 22-23.

34. Ibid., 22-23; Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 37.

35. "Technical Air Operations, Operation BUSTER/JANGLE," 8, 15, 24-25.

36. Ibid., 8-9, 15; Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 84.

37. "Technical Air Operations, Operation BUSTER/JANGLE," 9, 16.

38. Ibid., 9, 16; Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 84.

39. Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 90; "Technical Air Operations, Operation BUSTER/JANGLE," 9, 17.

40. "Technical Air Operations, Operation BUSTER/JANGLE," 17.

41. Ibid., 13, 26; Hatlem, Special Weapons Command Participation in Operation BUSTER/JANGLE, 38.

42. "Technical Air Operations, Operation BUSTER/JANGLE," 26.

43. "History of the Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER, April-June 1952," Vol. I of the Hist. of AFSWC, 12 Jan. 1953, i-iii, in Hist. Div. files.

44. Ibid., 316; rpt., "Participation of 4925th Test Group (Atomic) in Operation TUMBLER/SNAPPER, 16 January 1952-29 February 1953," prep. by Lt. Col. P. H. Fackler, 4925th TG (A), in Hist. Div. files.

45. "History of the Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 53-55.

46. Ltr., Dr. Graves to CG, SWC, 19 Dec. 1951, n.s., in J-11 files, Dr. H. F. Plank, LASL.

47. Ltr., Dr. Plank to Dr. W. D. Urry, Asst. for Atomic Energy, DCS/O, USAF, 9 Jan. 1952, subj.: Cloud Sampling Aircraft, see App.

48. Ltr., Col. Hooks to DCS/D, USAF, n. d., subj.: Aircraft for Sampling, in J-11 files, Dr. Plank, LASL.

49. Ltr., Dr. Graves to Col. K. E. Fields, Dir. of Mil. Applications, AEC, 19 Jan. 1952, subj.: Aircraft for Sampling, see App.

50. Ltr., Col. Fields to Brig. Gen. Bunker, 19 Feb. 1952, subj.: Manned Aircraft, see App.

51. Ltr., Col. Hooks to Dr. Graves, 28 Jan. 1952, subj.: Fighter Aircraft for Cloud Sampling, see App.

52. "History of the Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 58, 101, 139, 145; "Participation of the 4925th Test Group (Atomic) in Operation TUMBLER/SNAPPER, 1 March 1952-31 March 1952."

53. "History of the Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 84-85.

54. Rpt., "Test Air Operations Report for TUMBLER/SNAPPER," prep. by Test Acft. Unit, n. d., in Hist. Div. files.

55. "History of the Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 103, 140.

56. "Participation of 4925th Test Group (Atomic) in Operation TUMBLER/SNAPPER, 1 March 1952- 31 March 1952," in Hist. Div. files; "Test Air Operations Report for TUMBLER/SNAPPER."

57. "History of Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 66.

58. "Test Air Operations Report for TUMBLER/SNAPPER," [TUMBLER/ABLE X Ray (Dry Run)].

59. Ibid.; "History of Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 148.

60. "Test Air Operations Report for TUMBLER/SNAPPER," (TUMBLER/BAKER).

61. *Ibid.*, (TUMBLER/CHARLIE).

62. *Ibid.*, (TUMBLER/DOG).

63. *Ibid.*, (TUMBLER/EASY); "History of Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 150-151.

64. "Test Air Operations Report for TUMBLER/SNAPPER," (TUMBLER/FOX).

65. *Ibid.*, (TUMBLER/GEORGE).

66. "History of Air Force Special Weapons Center Participation in Operation TUMBLER/SNAPPER," 82-83; "Technical Air Operations, Operation TUMBLER/SNAPPER," Jan. 1953, Annex D, pp. 3-D - 6-D, in Tech. Info. & Intel. Lib.

CHAPTER III

OPERATION IVY

In January 1950, the Los Alamos Scientific Laboratory began work on a thermonuclear weapon. Within eighteen months, development was far enough along that a test detonation could be planned. For this purpose, Joint Task Force 132 formed in July 1951, and in January 1952, the Air Force established Task Group 132.4 at the Special Weapons Command and placed Brigadier General Frederic E. Glantzberg in command.[1]

Aircraft For Sampling

Because of the enormous cloud expected, Los Alamos Scientific Laboratory requirements for IVY sampling called for six sampling aircraft for altitudes above 43,000 feet. Samples from lower altitudes would not give a true picture of what was in the cloud. The sampling aircraft should be capable of flying five hours, two hours of which would be orbiting and sampling in the vicinity of the cloud. The laboratory recommended a cockpit filter system to protect the crew. The control aircraft for the sampling mission should operate above 30,000 feet altitude and be capable of flying at least 10 hours.[2] Dr. Plank outlined these altitude requirements for sampling the "super" bomb's cloud and declared that six B-47 aircraft were needed for the basic mission. Because of the unknown amount of fission product fractionation that would occur, he continued, ". . . it is desired to use as many of the B-47B aircraft in excess of the basic six as are operational on shot day." Concurrently, filter equipment for the B-47B aircraft was being developed by Los Alamos.[3]

Acting upon these plans, the Special Weapons Command submitted a request to higher levels for the B-47-type aircraft, but was turned down on 6 February 1952. First, there was not enough ground handling equipment to support the B-47 aircraft overseas, production on the aircraft was lagging about nine months, and, finally, the B-47 bomber required at least a 11,000-foot runway for safe operation. This latter point was important because there was only a 6,700-foot runway at Kwajalein Island. Another sampling aircraft had to be found.[4]

Task Group 132.4 officers began by considering the B-36, the B-45 bomber, F-89, and F-94 fighter-type aircraft. When data were compiled a conference was held with Los Alamos personnel on 15 February 1952, where Lieutenant Colonel Carl A. Ousley, on the planning staff of Task Group 132.4, explained the merits of each aircraft. He discussed availability, performance, runway requirements, communications equipment, maintenance requirements, and reliability. Thereupon, the confrees decided on the huge B-36 bomber. Again, request went forward to Air Force headquarters.[5] Still the IVY planners had trouble for on 21 February 1952, General Curtis E. LeMay declared that B-36 aircraft could not be used because this would interfere with the war plan for the Strategic Air Command. In rapid order the other aircraft were eliminated. The B-45 was also important to the war plans and, besides, would be unable to operate from the Kwajalein runways with the fuel load it would need to accomplish the sampling missions. Both the F-89 and the F-94 aircraft did not meet the desired characteristics. Meantime, forming of the Test Aircraft Unit stopped pending selection of the sampling aircraft.

Late in February 1952, General Glantzberg flew to Washington to push for a decision. And on 28 February 1952, the General wired the staff at Kirtland that they would use the F-84G single place fighter-bomber which would also serve as an escort-fighter or an interceptor-fighter. The aircraft, with an ejection seat, anti-G suit provisions, windshield defroster system, automatic fuel transfer and in-flight refueling system, had been first accepted by the Air Force in June 1951, and was considered a first-line combat aircraft. Task Group 132.4 then initiated plans for in-flight refueling for the F-84G aircraft, along with plans for instruments and navigational aids to be installed on them. The Air Materiel Command modified the 16 F-84G aircraft to a sampling configuration after Wright Air Development Center provided one aircraft as a prototype. On 18 May 1952, all but two of the aircraft flew from Bergstrom Air Force Base to the Mobile Air Materiel Area where they were to have F-5 autopilots installed, along with ARA-9 ultra high frequency homing devices, and radiac instruments. Wright Air Development Center delivered the prototype airplane to Mobile on 23 May 1952, and the final aircraft, just finished sampling during Operation TUMBLER/SNAPPER, arrived in Mobile the next day.

By early July 1952, modifications were completed, except for a few items not available to be installed at Mobile. The sampling tanks were delayed by negotiations for a contract. Throughout this period the sampling unit was flight testing the aircraft and turned up a multitude of minor discrepancies but these were hunted down and corrected. The prototype sampler cost $22,760 to modify while each of the other 15 aircraft cost $19,260.[6] Concurrently, the control aircraft were modified and sent to Wright Air Development Center for flight testing and from there to Walker Air Force Base, New Mexico, early in August 1952.[7]

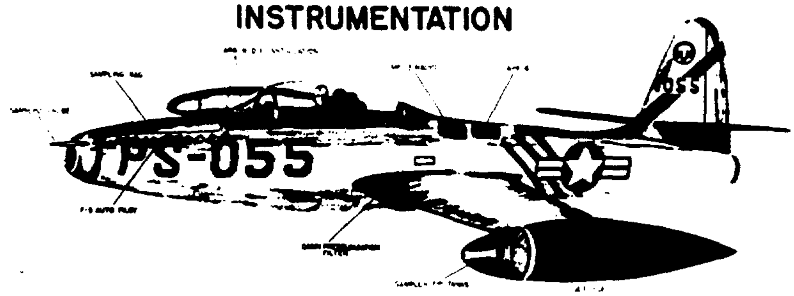
Training For Sampler Pilots

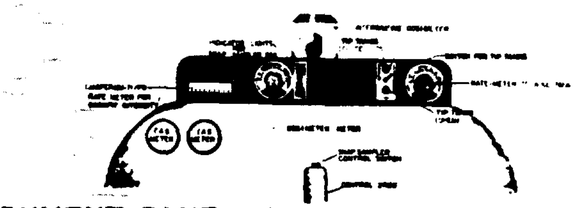
On 2 March 1952, Dr. Plank visited the Special Weapons Command when plans were drawn up for training the F-84G pilots to sample atomic clouds. Also, a letter from Los Alamos Scientific Laboratory formally requested that the Task Group 132.4 sampler pilots be allowed to participate in TUMBLER/SNAPPER and the Center approved the program on 26 March 1952.[8] During one of his visits, Dr. Plank explained the reasons and theories behind cloud sampling. The Strategic Air Command pilots picked to fly the F-84G sampler aircraft were pleased to learn that they were doing something useful, ". . . not serving as guinea-pigs as they seriously believed when first called upon to do the sampling."[9]

In late March and early April 1952, the F-84G pilots passed through Kirtland for a short period of training in theory of radiation and in the use of radiac instruments. Afterwards, in groups of five, they took additional training at Indian Springs Air Force Base where, as noted previously, they penetrated atomic clouds during the TUMBLER/SNAPPER detonations. To avoid excessive radiation which might inhibit sampling during Operation IVY, they were restricted to 0.1 roentgen exposure. Each group of five pilots remained at Indian Springs for one week in all and continued their studies on radiation and radiac instruments. In addition, ten maintenance personnel accompanied the pilots.[10] After completing this training, the 8th Air Force outlined sixteen training missions for the sampler pilots, emphasizing navigational flights of about 2,000 miles distance, rendezvous with tanker aircraft both by day and by night, weather penetration flights and flight formation drills.[11] Finally, on 13 August 1952, the sampler aircraft took off from Bergstrom Air Force Base and ran through a complete simulated mission. It flew to the control B-29 aircraft, then to the B-36 sampler controller, simulated sampling missions, then returned to the B-29. Pilots would complete the in-flight refueling exercise twice during a mission. All the F-84G samplers participated in the drill, along with three control aircraft, and ten KB-29 tankers.[12]

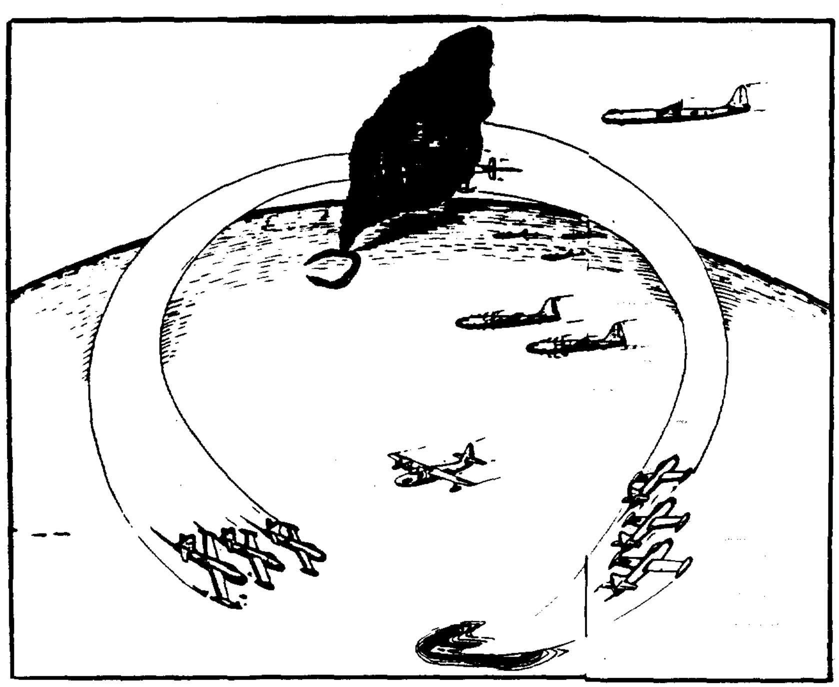
Training ended early in September and on 4 September, the 16 sampler aircraft took off from Bergstrom Air Force Base and flew to the Naval Air Station at San Diego, California. Enroute they rendezvoused with tanker aircraft and refueled. On the West Coast, the samplers received protective spray, were loaded aboard the aircraft carrier USS Rendova, and sailed for the Pacific Proving Grounds, arriving at Kwajalein on 30 September 1952.[13] The Pacific Command had turned down proposals for flying to the test site, because it would cost too much to station picket ships along the route to rescue pilots should any of the jets be forced down.[14]

F-84G SAMPLER AIRCRAFT INSTRUMENTATION





INSTRUMENT PANEL F-84G SAMPLER AIRCRAFT



Aircraft Pattern For Collecting Cloud Sample, Operation IVY

Unloading the F-84G aircraft from the USS Rendova posed further problems. Because the water in the Kwajalein lagoon was not deep enough to allow the ship to tie up to the pier, the aircraft were moved to a barge. Unloading was complicated in that the aircraft were lifted off the decks of the carrier by the ship's crane and lowered over the side. With two aircraft, the barge moved to the beach where a crane then lifted them to the beach. Two hundred yards away was the taxi strip. After tugs parked the aircraft, maintenance crews of the unit began preparing the aircraft and within two days of being set ashore, they were checked over and test flown.[15]

Sampling Operation IVY Shots

The pilots of the sampling unit made familiarization flights and rehearsals over the Pacific Test Site while waiting. It was soon discovered that clouds and rain might cause them to land at Eniwetok. During the actual sampling mission the aircraft would have landed at Eniwetok if Kwajalein was having rain because the water destroyed the filter papers.[16]

MIKE Shot. The first thermonuclear device ever fired, occurred on the morning of 1 November 1952. Two F-84G aircraft "sniffers" climbed to 40,000 feet altitude and met the primary B-29 control aircraft about 50 miles southeast of ground zero, ten minutes before the event. They refueled and proceeded under control of the B-29 until making visual contact with the B-36 control aircraft and orbited until the detonation after which they climbed as high as possible and reported height and intensity of the cloud. The control aircraft directed them into portions of the cloud for samples. When they had finished, the two "sniffers" flew back to the B-29 control aircraft for refueling before flying to Kwajalein.

The F-84G samplers formed three flights of four aircraft each, named Red, White and Blue. The Red flight arrived in the sampling area 90 minutes after detonation and rendezvoused with the control B-29 at 40,000 feet altitude. They were refueled at the intermediate refueling station, over the control destroyer; after which the B-36 sampler control directed them in sampling. The four aircraft of White flight took off three hours after detonation and proceeded to their missions without incident. The Blue flight took off four and one-half hours after detonation and took samples. Upon request of Dr. Plank, Blue 3 and Blue 4 aircraft were held in the sampling area for additional penetrations. Consequently, the two aircraft were in the air one and one-half hours longer than planned.[17]

The bottom of the mushroom head was at approximately 55,000 feet altitude, according to the previous report of the two "sniffer" pilots, which meant the F-84G could not gain enough altitude to sample it. Sampler Element commander, led Red flight. He climbed to 42,000 feet, the maximum altitude for the F-84G aircraft, and was directed by Dr. Plank to

PRIVACY ACT MATERIAL REMOVED

enter a small segment extending from the stem. This was approximately an hour and 40 minutes after detonation. and his wing man turned and flew toward the cloud stem for about 15 minutes before they made contact. The cloud was apparently so massive that, although the B-36 control aircraft appeared very close, it was actually about 100 miles from the cloud. When he reached the cloud, was in for a busy time. First, the sampler pilots had to fly the F-84 on instruments. Then there were three radiation instruments to read, remembering critical information to be entered on the report sheet and at the same time read off to Dr. Plank in the control aircraft. Also, each sampler pilot carried a stop watch to time his stay in radiation over one roentgen in intensity. Inside the cloud was impressed with the color. It cast a dull red glow over the cockpit. His radiac instruments all "hit the peg." The hand on the integron, which showed the rate at which radioactivity was being accumulated ". . . went around like the sweep second hand on a watch . . . and I had thought it would barely move!" reported. With "everything on the peg" and the red glow like the inside of a red hot furnace, made a 90-degree turn and left the cloud. He had spent about five minutes in radiation over one roentgen intensity. He reported to Dr. Plank, collected his wing men, and headed for the B-29 control aircraft for refueling, then returned to Kwajalein.[18]

Sampler Aircraft Accident on MIKE Shot. One of the critical elements of the sampling mission for Operation IVY was fuel for the F-84 aircraft. When the load was down to 1,500 pounds, the sampler pilot came down from his altitude and rendezvoused with the tanker aircraft. The pilot had 500 pounds of this fuel with which to find the tankers. If his fuel load dropped to 1,000 pounds and he did not have the tankers in sight, he was to proceed to Eniwetok and land. At altitudes above 40,000 feet, the F-84G aircraft used approximately 1,200 pounds of fuel an hour.[19] This F-84 fuel problem was the major contributing factor in an accident which was fatal to the pilot during the sampling of MIKE Shot.

PRIVACY ACT PROTECTED

MATERIAL REMOVED

Apparently, while inside the cloud, the airplane had stalled out and gone into a spin. instructed Red 3 and Red 4 to get together and return to the B-36 control aircraft, then start for the tanker aircraft. Both pilots acknowledged the instructions and switched to a different radio channel. did not contact the two aircraft after that.[20]

Neither one of the two pilots could find the control aircraft or the tankers. Their APX-6 equipment was not operating and was unable to pick up the control B-29 beacons. When he first contacted the control aircraft, he was down to 1,000 pounds of fuel, and should have been taking off for Eniwetok. The big problem was that could not pick up any beacons which would tell him what course to set for Eniwetok. Several times the B-29 control tried to direct to a rendezvous with it but finally instructed him to descend to 20,000 feet altitude and then orbit. On several occasions he was given orbit and steer instructions when the B-29 air controller believed he was in the vicinity of the tanker aircraft. Meanwhile, the Red 3 pilot picked up the Eniwetok radio beacon on his radio compass and started for the island with 600 pounds of fuel. He was approximately 96 miles north of the island. Shortly, reported his radio compass was working and that he had the beacon from Eniwetok. The B-29 controller instructed him to head for the island. "It was believed that he had between 400 and 500 pounds of fuel remaining at that time," the flight safety officer reported later. Unfortunately, Eniwetok was about 0.70 per cent overcast with rain squalls in the area at the time, although Red 3 aircraft landed with zero fuel remaining.[21]

When he received his second steer from Eniwetok, reported he was at 19,000 feet altitude, his engine still operating, but his fuel gage indicated empty. A few minutes later, he called the Eniwetok tower to report his engine had just flamed out and that he was at 13,000 feet altitude. When he was at 10,000 feet, Eniwetok tower thought he would make the runway. He had the island in sight. was given another steer to the runway. When he was at 5,000 feet altitude, he reported he could not make the runway and planned to bail out at 3,000 feet. He radioed: "I have the helicopter in sight and am bailing out."

The Air-Sea Rescue helicopter pilot spotted the F-84 between 500 and 800 feet altitude just north of the atoll. The aircraft was in a level glide at about 150 knots speed. The helicopter pulled in behind the jet and followed it toward the island, the pilot observing the tip tank release and what appeared to be the canopy. The aircraft continued in the glide, apparently under control, and struck the water slightly tail down, with the right wing a bit low. Neither the dive brakes, flaps, or the wheels were down. The F-84 skimmed over the water from 100 to 300 yards before hitting again. But on second contact, the nose dug in and the aircraft flipped onto its back. Approximately one minute later the helicopter was over the spot. The aft section of the F-84 was still visible, but sinking rapidly. The helicopter slowly circled the area, while calling for aid. Other units arrived and a thorough search of the area followed. An oil slick, one glove, and several maps appeared but was never found. The sampler aircraft had struck the water about three and one-half miles from the end of the runway on Eniwetok.

The flying safety report on the accident concluded that had spun out while sampling the cloud because he overtaxed the autopilot. The climb back to altitude cost a lot of fuel. He was then kept in the control area hunting the tanker aircraft too long. The accumulation of these troubles might have caused the pilot to use bad judgment during the rest of the flight. Had he maintained 20,000 feet altitude on his flight to Eniwetok, there was good chance he could have landed the aircraft, the investigators believed.[22]

KING Shot. As a result of the accident refueling plans for KING Shot changed. The primary refueling operation was to be in the cloud area, while the secondary refueling area was within sight of Eniwetok. There was added an emergency refueling area between the two. If the pilot could not take on fuel in the primary area, near the cloud, he would immediately fly to Eniwetok and make a second attempt. This failing, he would land his aircraft at Eniwetok. The new plan directed that no aircraft land at Eniwetok with less than 500 pounds of fuel aboard.[23]

Control, tanker, and sampler aircraft did not take part in the rehearsal for KING Shot, held on 9 November 1952. The second shot was scheduled for November 13, but bad weather pushed the date to 16 November 1952. The sampling missions came off without incident except that two of the samplers aborted. The White 3 aircraft took off from Kwajalein but could not retract landing gears and was forced to land again when back-up F-84 took off as a replacement. Then White 4 aircraft had a fuel pressure malfunction and was forced to return to Kwajalein. Because two F-84 aircraft were required to complete one sample collection, the spare aircraft also returned to base.[24]

Radiological Safety During Operation IVY

The first area on Kwajalein for decontamination of aircraft was on the parking ramps. This was near an engine run-up area and was considered unsuitable because engines might spread contamination over a wide area, the asphalt paving could absorb contamination, and drainage was not suitable conducting off washing solutions. Dr. Plank and the Rad-Safe officers of Task Group 132.4 recommended that another area be found for contaminated aircraft. They recommended a site and estimated cost of building the necessary facilities was $76,900. In April 1952, Joint Task Force approved the construction.[25] The parking area for contaminated aircraft was on the old Japanese parking area across the runway from the control tower on Kwajalein.[26] Here Air Force personnel removed the particulate samples from the F-84G samplers under the direction of Dr. Plank. The gas samples were removed from the AFOAT-1 aircraft by people from the Army Chemical Center.[27] The Rad-Safe crews took care of film badges worn by the sampler pilots and by personnel working in the area. No sampling pilot on Operation IVY exceeded the radiation limit of 3.9 roentgens.[28]

Roll-Up Of Operation IVY

As the operation terminated, some suggested the sampler F-84 aircraft be flown to the United States but this plan was dropped. Personnel towed the aircraft to the beach, lifted them onto the barge, towed to the side of the aircraft carrier, USS Rendova, and lifted each aboard with the ship's crane. One of the aircraft sustained very minor damage when it swung against the side of the ship while being lifted to the flight deck. The ship and aircraft sailed for the United States on 21 November 1952. Roll-up personnel crated and shipped the instruments and sampling equipment, separately, to the Los Alamos Scientific Laboratory.[29]

Afterwards, Task Group 132.4 started action through Air Force headquarters to retain the sampler and control aircraft which had been modified for Operation IVY since these would be needed for future tests. Meanwhile, as the F-84G samplers arrived in the United States, they were returned to the Strategic Air Command at Bergstrom Air Force Base, Texas.[30] General Glantzberg recommended: ". . . that the sampler aircraft, the control aircraft, the instrumented B-50 aircraft, and the effects measuring B-36 and B-47 be retained in their present configuration. The savings in money, time, and equipment are obvious."[31]

CHAPTER III

NOTES

1. MSgt. Max Gerster, The Special Weapons Center and Atomic Testing, AFSWC Hist. Div., Jan. 1957, 112-113; Narrative History of Task Group 132.4, Provisional (IVY), 1 July 1951-29 February 1952, 6, in Hist. Div. files, Operation IVY.

2. Narrative History of Task Group 132.4 (P), (IVY), 1 March-30 April 1952, 46-47, in Hist. Div. files, Operation IVY.

3. Memo., to R. T. Lunger, LASL, prep. by Dr. H. F. Plank, LASL, n.d., subj.: Basic Plan for Cloud Sampling by B-47's at Operation IVY, in J-Div. files, LASL.

4. Narrative History of TG 132.4 (P), (IVY), 1 July 1951-29 February 1952, 23-25.

5. Ibid., 1 March-30 April 1952, 47-50; 1 July-31 August 1952, 41; 1 July 1951-29 February 1952, 23.

6. Ibid., 1 March-30 April 1952, Tab A; 1 July 1951-29 February 1952, 23-24.

7. Ibid., 1 July-31 August 1952, 41.

8. Ibid., 1 March-30 April 1952, 53.

9. Memo., to Col. P. Hooper, J-3, prep. by Maj. R. E. Keegan, Asst. J-3, Air, 24 Mar. 1952, subj.: Trip Report - Kirtland AFB-18-19 March 1952, in J-Div. files, LASL.

10. Narrative History of TG 132.4 (P) (IVY), 1 March-30 April 1952, 53-56, 71-73, Tab B.

11. Ibid.

12. Ibid., 1 July-31 August 1952, 51-53.

13. Ibid., 1 September-31 October 1952, 76.

14. Ibid., 1 March-30 April 1952, 31.

15. Ibid., 1 September-31 October 1952, 22-23; 1 March-30 April 1952, 33.

16. Ibid., 1 September-31 October 1952, 50-51.

17. Rpt., "Air Task Group Participation in MIKE Shot, Operation IVY," (Special Installment for MIKE Shot), prep. by Capt. C. C. Gorham, Hist. Off., TG 132.4 (P) (IVY), 1 Nov. 1952, 5-7, 11, in Hist. Div. files, Operation IVY, see App.

18. Ibid., 7-8.

19. Ibid., 5-7.

20. Ibid., 8.

21. Ibid., 8-11.

22. Ibid., Annex C, 10.

23. (Special Installment for KING Shot), TG 132.4 (P) (IVY), 16 November 1952, 6, in Hist. Div. files, Operation IVY.

24. Narrative History of TG 132.4 (P) (IVY), Final Installment, 16 October-31 December 1952, 50-51; (Special Installment for KING Shot), TG 132.4, 5, 8, 16-17.

25. Narrative History of TG 132.4 (P) (IVY), 1 March-30 April 1952, 56-58.

26. Ibid., Final Installment, 16 October-31 December 1952, 32.

27. Ibid., 1 September-31 October 1952, 61; 1 July-31 August 1952, 45.

28. Ibid., Final Installment, 16 October-31 December 1952, 30-31.

29. Ibid., 17, 28.

30. "Final Report, Task Group 132.4 (P) (IVY), January-December 1952," 86-87, in Hist. Div. files, Operation IVY.

31. Ibid., 89.

CHAPTER IV

SAMPLING OPERATION UPSHOT/KNOTHOLE

Late in 1951, the Armed Forces Special Weapons Project recommended a series of nuclear tests to be conducted at the Nevada Test Site to determine the effects of nuclear detonations on military equipment and some types of structures. This series of tests, called KNOTHOLE, was approved by the Joint Chiefs of Staff in December 1951, and scheduled for April 1953. While Operation TUMBLER/SNAPPER was being conducted, the Los Alamos Scientific Laboratory proposed a development test operation, Operation UPSHOT, to be conducted in Nevada in the fall of 1952. These tests received approval also and became combined with the KNOTHOLE tests, but delayed until 1953.[1] Intensive planning for Operation UPSHOT/KNOTHOLE was under way by December 1952, as soon as Operation IVY ended in the Pacific.

Sampling Planning

Colonel Daniel E. Hooks, Chief of Staff at the Air Force Special Weapons Center, wrote the commander of the 4925th Test Group (Atomic), outlining functions which would be required during the test series. Among these duties were provisions for sampling aircraft, control aircraft, and crews, in all about nine sampling aircraft.[2] In return, Colonel Osmond J. Ritland, commanding the test group, asked that nine F-84G aircraft, modified for cloud sampling, be assigned to his group. In addition, Colonel Ritland asked for one T-33 aircraft with which to train personnel in sampling techniques. The 4925th also needed 18 qualified

F-84 pilots. These pilots were to arrive at Kirtland Air Force Base on 2 February 1953 to begin training and were to be put on temporary duty with the group.[3]

In December 1952, Colonel Karl H. Houghton, Human Factors Branch, Research and Development Division, Deputy for Operations, Lieutenant Colonel Fackler, Plans and Operations Division of the 4925th Test Group (Atomic), and Dr. Plank of Los Alamos met over the sampling problems expected for Operation UPSHOT/KNOTHOLE. The length of exposure of the samples to be gathered from the nuclear clouds was determined by the use these samples would receive by the various laboratories. The Atomic Energy Commission's Biological-Medical Division declared that 3.9 roentgens accumulated exposure was the limit for any individual during the test. Therefore, the radiation exposure a pilot could absorb for each shot was figured very closely. There were ten shots scheduled and to gather required samples from the first five shots, pilots would be exposed to a total of 2.9 roentgens. For the samples needed from the second five shots, the pilots would have to take a total radiation dosage of 2.9 roentgens. But an eleventh shot was added to the series and this dosage increased to 3.1 roentgens. These figures were for radiation received while actually in the cloud and did not include radiation absorbed while near the cloud or while flying the sampler. These factors convinced the two colonels and Dr. Plank that two groups of pilots were necessary for the program; one group to sample each half of the test. Also, to stay within the limits of the allowable dosage, all secondary sources of radiation had to be reduced as much as possible. One of the ways for doing this was to polish the surfaces so that contaminated particles could not cling to the aircraft.[4] Dr. Alvin C. Graves, Test Director for Los Alamos Scientific Laboratory, wrote the Special Weapons Center to emphasize these points.[5] And, on the basis of this letter, the Center's staff took action to obtain F-84 sampler aircraft and pilots.[6]

The 4925th Test Group (Atomic) underwent some adjustment for UPSHOT/KNOTHOLE. During testing in Nevada, operations, maintenance, and personnel for sampling had been secured at the test site on a shot-to-shot basis. The new plan was to organize a provisional unit to furnish these personnel and functions at all times. The 4925th established Operations Unit Number One (Test) Provisional on 23 February 1953 under Lieutenant Colonel James A. Watkins. The new organization would not only secure personnel and equipment for the support of the tests in Nevada but also train personnel and execute modifications on the F-84 sampler aircraft.[7] When the unit was finally located at Indian Springs Air Force Base, it had nine F-84 sampler aircraft, one B-50 sampler control aircraft, and two B-29 samplers.[8]

The F-84G aircraft for sampling moved to Kirtland Air Force Base while the pilots came from Strategic Air Command and from the 4925th. Many were fighter pilots returning from Korea. Of the twenty who finally flew sampler missions during Operation UPSHOT/KNOTHOLE, only two had had previous experience and could lend advice. These were Captain Wilburn S. Rose and Captain Harvey S. Stockman who had been with the Test Aircraft Unit during IVY.[9]

Because the radiation exposures assumed this importance, each aircraft carried an instrument to tell the pilots instantly how much radiation they absorbed. The Los Alamos Scientific Laboratory designed an integron which performed this requirement. On the basis of indications registered on the device, the sampler pilot knew when to break away during a sampling run. The monitor was carefully calibrated before each sampling mission and served as the primary instrument for sampler pilot use. For a further check on readings, film badges were placed about the cockpit and on the pilot. F-84 samplers also carried rate meters which indicated peak intensity of radiation fields at any one time, and an ion chamber which measured the radiation approximately one foot from the filter papers in the wing tips of the aircraft and relayed the information to an indicator in the cockpit. Through this instrument the pilot evaluated the samples collected during his mission.[10]

In late February 1953, test personnel with their equipment moved from Kirtland to Indian Springs. On 3 March 1953, the F-84G sampling aircraft pilots, and crews arrived at Indian Springs and preparations began.[11]

The Special Weapons Center controlled all aircraft around the test site.* [12] All air operations during the test were directed from the Atomic Energy Commission's control point on the Nevada Proving Grounds, and

*In February 1953, the Air Research and Development Command directed that the Center should take control of all air operations connected with the testing of nuclear weapons in Nevada.

Lieutenant Colonel Fackler, as special projects officer, handled the air controller's functions with a staff of two officers and two airmen. The colonel, probably the most experienced man in controlling aircraft during nuclear testing, was assisted by officers from the Special Weapons Center: Colonel Kurt M. Landon, Vice Commander, and Lieutenant Colonel James S. Starkey, Special Project Officer, rotated this assignment.[13]

Sampling the Shots

Again as in previous operations, routine for a shot began the day before. All aircrews participating received briefings on their missions and weather. Specialized briefings were held at the Test Operations Unit Number One briefing room, aircrews received badges and dosimeters, and the ground crews installed filter papers into the holders on the wingtips of the F-84G samplers.

On the morning of the shot, the test operations unit's personnel controlled all takeoffs and landings from Indian Springs and directed aircraft to the Nevada Proving Grounds. At the control point, inside the testing grounds, Colonel Fackler's air controllers took over and directed the aircraft during their stay over the test site. Aboard the B-50 sampler controller aircraft, Los Alamos Scientific Laboratory personnel (usually Dr. Plank) directed the actual cloud penetrations of the sampler pilots. Dr. Plank watched the radiation exposures and as soon as the pilots approached allowable dosages, directed them to return to Indian Springs. After landing they taxied to the east end of the field where radiological monitors determined the extent of contamination on the aircraft. The pilots were removed from the aircraft ". . . in such a way that their bodies did not touch the skin of the craft at any time." The pilot then proceeded through the decontamination center. If contaminated, he took a number of showers, while personnel prepared his clothing for shipment to Camp Mercury the decontamination laundry. The radiation acquired by the individual was then recorded on his dosage record and the accumulated dosage carefully checked to keep the individual from exceeding the safety limits established by the Atomic Energy Commission.

Meantime, filter recovery crews removed the sampling papers from the aircraft and prepared them for shipment on courier aircraft to the various laboratories. Speed in performing this work was necessary for the laboratories had to run tests on the filter papers before they were able to determine what happened during a detonation. Information gained from these papers decided the actual yield of the shot, speed of the reaction, and the amount and type of fission which had occurred.

The sampler aircraft "cooled" overnight and the next day was decontaminated. Maintenance crews washed each aircraft repeatedly with "Gunk", a special chemcial washing compound. When clean they moved onto the parking ramp for routine aircraft maintenance. Here personnel removed the radiological instruments, checked, and recalibrated for the next mission.[14]

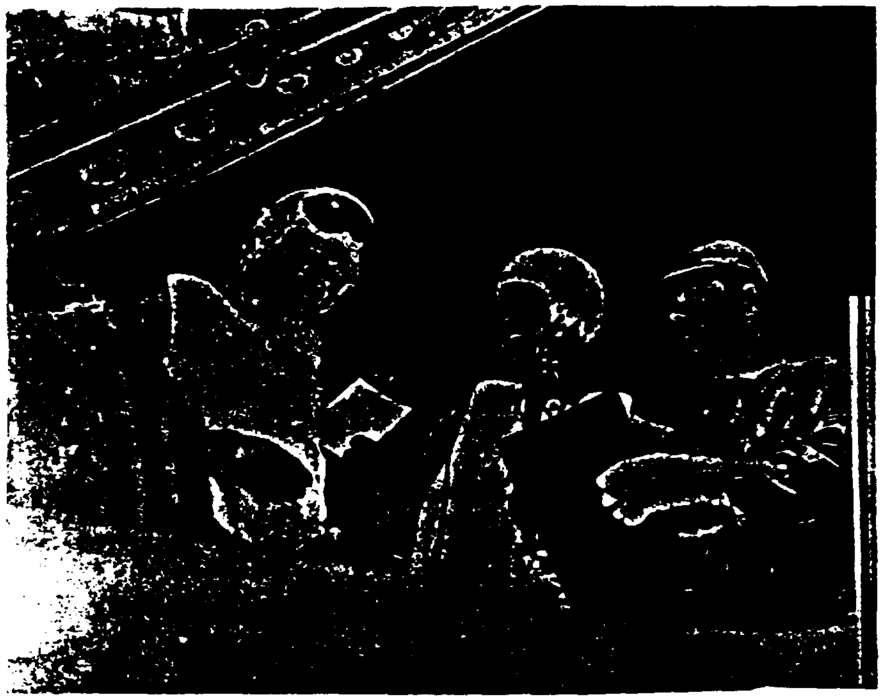
Chart: Shots for UPSHOT/KNOTHOLE

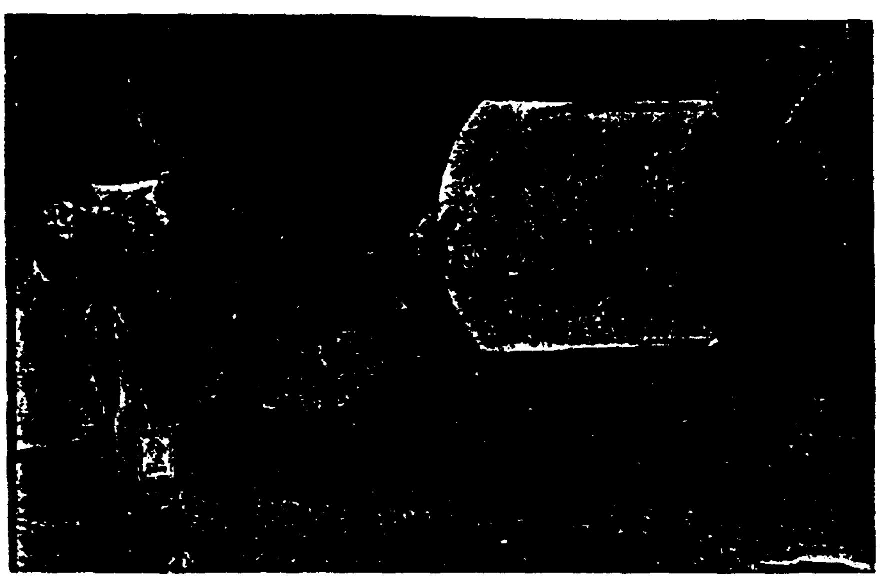
Shot	Date	Type
ANNIE	17 March 1953	300-foot tower
NANCY	24 March 1953	300-foot tower
RUTH	31 March 1953	300-foot tower
DIXIE	6 April 1953	Air drop
RAY	11 April 1953	100-foot tower
BADGER	18 April 1953	300-foot tower
SIMON	25 April 1953	300-foot tower
ENCORE	8 May 1953	2,420 feet air drop
HARRY	19 May 1953	200-foot tower
GRABLE	25 May 1953	500 feet in air
CLIMAX	4 June 1953	Air drop

Even with two groups of sampler pilots, the radiation dosages were carefully calculated, based on the aircraft entering the cloud approximately two hours after detonation, on the predicted yield of the device, on a speed of 250 miles an hour, and upon clean aircraft.[15] Sampling officials took three major steps to reduce exposure. During the first mission, ANNIE Shot, the soundness of clean aircraft was clearly demonstrated. About half the exposure was absorbed between the last cloud penetration and the landing at Indian Springs. The aircraft had always collected "residual contamination" on outer surfaces. But after personnel cleaned the aircraft with acid brightener, the polished aircraft reduced radiation from 50 to about 17 per cent of the total. Secondly, radiation to the pilot was reduced through lining the interior of the cockpit with 1/32-inch sheets of lead. There was a delay obtaining this material but all the F-84 samplers received the lead by RAY Shot, 11 April 1953.

The third protective device was a lead-glass vest designed to cover the sides and front of the torso. This device, like most of the sampling equipment developed during this period, was the result of cooperation by Lieutenant Colonel Fackler, Colonel Houghton, and Dr. Plank. Dr. Plank estimated that the vest reduced dosages from 10 to 15 per cent. When the vest was actually tested during NANCY Shot, radiation appeared lessened by 17 per cent. Production of the vests was delayed because of limitation in personnel and equipment. However, there were enough vests available to fit all the sampler pilots for BADGER SHOT, on 18 April 1953.[16]

After the first shot of the series, one of the flying duties was taken away from the F-84 sampler pilots. Colonel Fackler and Dr. Plank worked out a system of airplane control whereby the navigator aboard the B-50 sampler control provided the sampler pilot with time and vectoring information. This relieved the F-84 pilots of the duties of navigating their aircraft from Indian Springs to the control airplane. When the sampling mission was finished, the B-50 navigator had the sampler's course plotted back to the base.[17]





Inserting filter unit into tip tanks of a sampler aircraft, Operation UPSHOT/KNOTHOLE.

By 18 April 1953, sixth shot, BADGER, the first group reached their radiation limits and passed sampling missions to a new group of pilots.[18]

On two occasions during Operation UPSHOT/KNOTHOLE, the samplers nearly failed to return with cloud samples. The first time occurred on 19 May 1953, during HARRY. The test director delayed the shot several times because of unfavorable weather. Samples from the shot were very important because of the new device being tested. Ten F-84G samplers and the AFOAT-1 two B-29 samplers flew the mission. Two "snooper" F-84 aircraft reported that the cloud topped 44,200 feet altitude and the base of the mushroom was at 29,000 feet altitude. The first jet sampler took off from Indian Springs Air Force Base and climbed south of the cloud area. By this time cirrus clouds had begun to form around the nuclear cloud. The sampler pilot came out of the cirrus at 44,000 feet altitude and could see only a dark smudge on top of the overcast. The F-84 pilot made passes into this dark smudge, obtaining the only samples from the main part of the HARRY cloud. Five other F-84 aircraft took samples from a thin part of the cloud below the overcast, but these samples were of low quality. Two other F-84 aircraft made no contact with the atomic cloud at all and the final two jets did not take off. The cirrus cloud formation extended from 50 to 75 miles and appeared solid from 28,000 feet to 43,000 feet altitude. Unfortunately, the samples obtained from the cloud were sufficient to do only the primary experiments scheduled.[19]

The GRABLE Shot was an atomic shell fired from an Army 280-millimeter artillery piece and as for the previous shot Colonel Fackler told the test director samples could not be guaranteed because of vapor clouds expected around the atomic cloud. As the atomic cloud drifted in the wind, vapor clouds became thicker and thicker. The B-50 sampler control aircraft, with Dr. Plank aboard, climbed above the overcast with little success in finding the atomic cloud. Back through the overcast there was approximately one-fifth of the atomic cloud below the vapor clouds. Dr. Plank called for the F-84 aircraft immediately and began directing them into this lower portion. The overcast continued to thicken and lower so that, after two-and-one-half hours following the detonation, sampling stopped. By that time the atomic cloud was some 300 miles from Indian Springs Air Force Base. Two aircraft took small samples, while the last aircraft which attempted to enter the cloud received none.[20]

Conclusions

Operation UPSHOT/KNOTHOLE sampling missions were not greatly different from the missions flown in former tests. The sampler functions, however, were more refined. Colonel Houghton, Lieutenant Colonel Fackler, and Dr. Plank had concentrated on methods of reducing the radiation dosages received by the sampler pilots so that larger, more valuable cloud samples could be obtained while the pilot personnel remained safely within the limits established by the Atomic Energy Commission.

CHAPTER IV

NOTES

1. MSgt. Max Gerster, The Special Weapons Center and Atomic Testing, AFSWC Hist. Div., Jan. 1957, 131, 133, in Hist. Div. files, AFSWC Histories.

2. Ltr., Col. D. E. Hooks, CofS, AFSWC, to CO, 4925th TG (A), 1 Dec. 1952, subj.: Assignment Responsibilities for Operation UPSHOT/KNOTHOLE.

3. Ltr., Col. O. J. Ritland, Cmdr., 4925th TG (A), to CG, AFSWC, 11 Dec. 1952, subj.: Assignment Responsibilities for Operation UPSHOT/KNOTHOLE.

4. Rpt., "Operation UPSHOT/KNOTHOLE, Nevada Proving Grounds, March-June 1953, Report to the Test Director, Aircraft Participation," prep. by Lt. Col. P. H. Fackler, 4925th TG (A), (Nov. 1955), see App.

5. Ltr., Dr. A. C. Graves, Test Dir., LASL, to CG, AFSWC, 12 Dec. 1952, subj.: Detailed Cloud Sample Requirements for UPSHOT/KNOTHOLE, see App.

6. "History of the Air Force Special Weapons Center Participation in Operation UPSHOT/KNOTHOLE, March-June 1953," prep. by AFSWC Hist. Div., 30 Apr. 1954, 8, in Hist. Div. files, Operation UPSHOT/KNOTHOLE.

7. Ibid., 12-13.

8. Rpt., "Historical Report, Operation UPSHOT/KNOTHOLE, 1 March-31 March 1953," prep. by 4925th TG (A), 3, in Hist. Div. files, Operation UPSHOT/KNOTHOLE.

9. "Operation UPSHOT/KNOTHOLE, Aircraft Participation," 19; ltr., Col. F. W. Miller, Dep. for Ops., ARDC, to CG, AFSWC, 12 Feb. 1953, subj.: Aircraft Positioning in Atomic Tests.

10. "Operation UPSHOT/KNOTHOLE, Aircraft Participation," Annex A, see App.

11. Rpt., "Historical Report, Operation UPSHOT/KNOTHOLE, 1 March-31 March 1953," 12.

12. Ltr., Col. Miller to CG, AFSWC, 12 Feb. 1953.

13. "History of the Air Force Special Weapons Center Participation in Operation UPSHOT/KNOTHOLE," 15.

14. Ibid., 14-15

15. "Operation UPSHOT/KNOTHOLE, Air Participation," Annex A, see App.

16. Rpt., "4925th Test Group (Atomic) Operational Summary Report, 1953, Continental Nevada Spring Tests, Operation UPSHOT/KNOTHOLE," Annex A, Sampling Activities and Techniques, in Hist. Div. files; interview with Dr. Harold F. Plank, J-Div., LASL, conducted by Warren E. Greene, AFSWC Hist., 26 Sep. 1957, see App.

17. "4925th Operational Summary Report, Operation UPSHOT/KNOTHOLE," Annex C, Nevada ZOMBIE Shot Summary.

18. "History of the Air Force Special Weapons Center Participation in Operation UPSHOT/KNOTHOLE," 38.

19. "4925th Operational Summary Report, Operation UPSHOT/KNOTHOLE," Annex J, HAMLET Shot Summary.

20. "History of the Air Force Special Weapons Center Participation in Operation UPSHOT/KNOTHOLE," 58-60.

CHAPTER V

OPERATION CASTLE ALL THERMONUCLEAR

Operation CASTLE was to contain about seven, all-thermonuclear detonations and begin about 1 September 1953, some 11 months following Operation IVY. Colonel Howell M. Estes, Jr., 12th Air Division of the Strategic Air Command, was to command the Air Task Group and, on 1 November 1952, he visited the Pacific Proving Grounds to observe the MIKE Shot.* In February 1953, Task Force 132, which conducted Operation IVY reformed into Joint Task Force SEVEN for Operation CASTLE and, shortly after became a permanent organization for future overseas test series.[1] Instrumentation and building at the Pacific Proving Grounds could not be started before the results of the UPSHOT/KNOTHOLE were known though much was prepared by November 1953. Since this was typhoon season in the Pacific, CASTLE tests were rescheduled for the spring of 1954. Air Force headquarters announced Operation CASTLE would begin at the Pacific Proving Grounds as soon as conditions permitted. General Mills organized the office of deputy commander for overseas tests and assigned the duty to Colonel Edward M. Gavin. Colonel Gavin worked closely with the Center staff for the interim between IVY and CASTLE. One of his major projects was to consider various airplanes which might meet new sampling requirements.[2]

---

*On 29 November 1952, Colonel Estes became Brigadier General, his new rank paralleled planning for Operation CASTLE.

V

Cloud Sampling Requirements for CASTLE

The stem from the first thermonuclear cloud was some 20 miles in diameter and climbed to almost 50,000 feet. The main cloud extended from 50,000 feet altitude on up through the tropopause and was almost 200 miles wide. The F-84G sampler aircraft climbed to their maximum altitude to collect samples from this monster. Scientists, however, doubted whether samples taken from MIKE cloud represented what was actually contained in the cloud. There was also uncertainty about whether the samples were taken from the stem or from the lower portions of the main cloud itself. The size of the MIKE cloud and these doubts about the value of samples taken from it, caused a change in requirements for sampling the Operation CASTLE shots.[3]

Within two weeks of the end of Operation IVY, Task Group 132.4 officers and the Air Force Special Weapons Center staff began studies to determine what aircraft could be converted to a sampler configuration for higher altitudes. But, before a decision could be made, sampling requirements had to be firm.

Late in January 1953, officers from the Air Force Special Weapons Center visited the Los Alamos Scientific Laboratory and again met with Harold F. Plank. Dr. Plank outlined general requirements for cloud sampling and, afterwards, drew up more detailed requirements which were approved by the laboratory and submitted to the new Task Force SEVEN early in February. Because of the questionable samples secured from MIKE Shot, Los Alamos wanted a high altitude sampling vehicle which could at least penetrate the lower portion of the main cloud. Data from these high altitude sampling missions could then be compared with MIKE samples to determine how representative the F-84G samples on IVY had been.

The sampling officers speculated that an aircraft to perform this high altitude mission would have to operate at or about 55,000 feet altitude for at least one-half hour, long enough to make several passes into the cloud. Should the samples prove against the F-84G aircraft, then another aircraft would be chosen to become the permanent sampling vehicle. Los Alamos scientists required, also, that the sampling device on the high altitude aircraft be as efficient as those mounted on F-84G aircraft, but with more area for sampling paper.[4]

Unmanned Samplers for CASTLE

Altitude limitations of sampling aircraft also caused some discussion about using unmanned vehicles again. Drones had gathered the first cloud samples. However, during Operation GREENHOUSE, Dr. Plank supervised firing rockets at atomic clouds. The experiment, at that time, resulted in no sampling results. [redacted] shot pushed the main cloud so high that even the best manned aircraft could hope for little more than to sample the lower fringes. Dr. Plank pointed out that the B-57, apparently the best of the available aircraft for sampling, would penetrate the cloud some four to six hours after detonation and expose its crew to about 3.5 roentgens. Samples gathered by a guided missile, or some other vehicle, would possibly be about ten times more valuable than those gathered by the B-57. Such an unmanned sampler should be capable of sustained horizontal flight between 55,000 and 75,000 feet altitude, Dr. Plank said, and be capable of flying at least 100 miles at these altitudes.

Colonel Gavin asked the Wright Air Development Center for information on guided missiles, test vehicles, or target drones which might fit these unmanned sampling requirements. Any such vehicle, he pointed out, would have to be capable of recovery over land. Lieutenant Colonel Richard S. Nugent, the colonel's administrative assistant, hand-carried the request to Wright Field and was able to get some preliminary information. Rocket vehicles would be difficult to adopt because of the problem of attaching adequate sampling devices to them. Also, they would be difficult to recover, especially when operating in the Pacific Proving Grounds.[5]

Joint Task Force SEVEN was also in favor of unmanned sampling devices. Brigadier General A. R. Walk, U. S. Army, Chief of Staff of the Joint Task Force, suggested that Los Alamos and the Center investigate the potentialities of the Q-2 drone and the drone B-47 aircraft used on BRASS RING.[*][6] Center officials pointed out, however, that the Q-2 drone could climb very little higher than the F-84G sampler aircraft and, because the advantage of the drone B-47 over available samplers was not very great, the logistics of operating at the Pacific Proving Grounds would be exorbitant.[7,8] Therefore, no serious attempt was made to secure unmanned samplers. However, while preparing a final report for CASTLE, General Estes asked the University of California Radiation Laboratory, at Livermore, California, what they thought an unmanned sampler should be like.[9]

Professor Kenneth Street and Roger Batzel, sampling experts from the

---

*A program to develop a prototype long-range automatic bomb delivery system.

Livermore Laboratories, believed a guided missile capable of operating between 80,000 and 100,000 feet altitude was needed. They wanted such a vehicle to enter the cloud between five and ten minutes after detonation and be capable of collecting both gas and particulate cloud samples. The vehicle, of course, should be recoverable, and have the ability to land on a 5,000-foot runway.[10]

In his final report on Operation CASTLE, General Estes pointed out that, because manned sampling aircraft were the best vehicles available, scientists were forced to accept them, even with their limitations. A study of guided missiles for sampling had not been accomplished during CASTLE because time was too short, missile experts were not available, and cloud temperatures, gusts, and radiation data were not available. General Estes recommended further study of guided missiles for this purpose, capable of operating from 100,000 to 125,000 feet altitude.[11]

Modifying Sampler Aircraft for CASTLE

In spite of the efforts for B-57 aircraft and the current thinking about guided missiles, Task Group 7.4 sampled CASTLE shots with F-84 jets, plus three Featherweight B-36 aircraft. Both types went to modification depots before being shipped to the Pacific Proving Grounds.

In August 1953, representatives of the Air Materiel Command, Wright Air Development Center, the Atomic Energy Commission, AFOAT-1, met at the Mobile Air Materiel Area depot to plan modifications needed for CASTLE. The F-84G samplers were to be rewired, have new electronic equipment installed, and to receive a new gas sampling device, called a "double-squeegee," installed in ten aircraft. A new type gamma intensity rate meter was to be installed in the cockpit of the fighters. The B-36 was to receive a filter system for the pressurization complex, along with a "double-squeegee," and a particulate sampling device. One of the B-36 aircraft received electronic equipment so it could be used as a backup for the B-36 controller. In the midst of these arrangements, equipment for installation was still in design stage. These were the "double-squeegees," high altitude gas sampling devices. However, engineers from the Wright Air Development Center assured that they would be ready when needed.

The Ogden Air Materiel Area depot, Utah, accomplished modifications to the F-84G samplers and planned to complete the work on 14 September 1953. The San Antonio Air Materiel Area depot, Texas, handled the work on the three B-36 aircraft, two samplers and one control aircraft, and planned to complete the work by 5 October 1953.[12]

There were serious delays. Ogden received the new "double-squeegee" devices and mounted them but the motors and pump shafts overheated and failed. Much work was necessary to find a fix for these failures and the F-84G sampler aircraft were delayed 99 days at the depot. The aircraft were finally finished and out of the modification facility just six days before they were to board the carrier for the Pacific Proving Grounds.

At San Antonio Air Materiel Area, meanwhile, the B-36 sampler modification program ran into trouble. The Tracerlab, Incorporated, designed the sampling devices for the big bombers but did not meet time schedules. This delayed fabrication of the units until some 40 days after the B-36 modifications were to have been completed. The Air Materiel Command established a "crash program" to get them installed on the aircraft and B-36 samplers came out of the depot on 25 January 1954, three days before they were scheduled to leave for the Pacific. The program had fallen behind a total of 112 days.

These delays wrecked a flight training program for the sampling squadron. The pilots conducted flight training with borrowed airplanes without the sampling instruments. When the crews of the squadron arrived at the Pacific Proving Grounds, they were required to fly much more to make up for lost training. The crews were concerned with basic procedures for sampling and should have been prefecting techniques. Extra flying imposed an added burden on the Test Aircraft Unit. Supplies and spare parts were used up rapidly and later caused troubles during the series.[13] Some of the delay, General Estes pointed out, was caused by requirements from numerous agencies which had been presented at the modification depot. In the future, General Estes recommended, the Air Force Special Weapons Center should be made the clearing house so that the modification depot received directions from only one agency. Also, design and equipment should be established on a deadline which would give the depot time to finish its work.[14]

One problem in the Operation CASTLE planning was securing F-84 sampler pilots to supplement those assigned to the new 4926th Test Squadron (Sampling). Colonel Edwin Gavin asked Joint Task Force SEVEN if it were possible to secure some of the pilots who flew sampling missions during

Operation IVY and offered to supply a list of names.[15] Later, in September 1953, scientist Plank attempted to get several IVY sampler pilots from the 8th Air Force but the Strategic Air Command could not release them for CASTLE. Later, the Strategic Air Command and the Air Defense Command were to supply eight F-84 pilots each to train as cloud sampler pilots with the 4926th and to accompany the squadron to Eniwetok. This caused some budget problems. Each military organization participating in the test series had to stand the cost of its participating unit. However, the two commands argued against paying the temporary duty costs of their eight pilots for CASTLE because the requirements had been levied on them too late to include these costs in their fiscal year 1954 budget. Task Group 7.4, therefore, asked the Joint Task Force for money, which in turn asked Air Force headquarters for the funds. Washington, in turn, decided that the Air Research and Development Command should foot the bill. Colonel Earl W. Kesling, who replaced Colonel Gavin as deputy commander for overseas tests at Center, reported that the Air Research and Development Command refused to pay these costs and the Special Weapons Center did not have the money. Hence, Task Force SEVEN planned to pay the expenses under protest, then would ask for reimbursement later. However, Air Force headquarters ordered pilots transferred to the 4926th Test Squadron (Sampling) on a permanent change of station. This actually returned the burden to the Air Force Special Weapons Center.[16]

The officer strength of the 4926th Test Squadron built up during the first months of 1953. In August and September, there were 20 officers assigned to the squadron. In September 1953, however, 10 officers were attached and in October, the squadron showed an officer strength of 38, with nine pilots. In November 1953, the official strength of the squadron settled at 40 officers and this remained its strength throughout Operation CASTLE.

A full-scale air rehearsal, occurred off the coast of California, 27 October 1953, and was called Operation TIGER/CAT. This test was to allow the Air Force and Navy aircraft to become acquainted with operational procedures for CASTLE and to check the communications networks. Any deficiencies were to be corrected within the three months before the series.[17]

During these maneuvers, the 4926th Test Squadron (Sampling) operated from the San Diego Naval Air Station. The F-84G aircraft took off from San Diego and flew some 50 miles to sea where they came under the control of the Command Ship, the USS ESTES, which vectored them to the B-36 sampler controller aircraft.[18] In turn, the controller directed the jets through simulated sampling maneuvers and returned them to the command ship which sent them back to San Diego. The rehearsal was important experience for the air-sea rescue aircraft. One of these aircraft flew directly under the B-36 sampler control, while another was under the control of the command ship. Mission aircraft would be no farther than 50 miles from emergency landing facilities at any time during the rehearsal. "This will be particularly appreciated by our little brothers in the F-84 thunder jets," a briefing officer declared, "who will be flying long range and endurance mission in single engine, high performance aircraft."

TIGER/CAT was successful. Communications equipment aboard the Command Ship, turned up many malfunctions and the ship put into San Diego immediately after the exercise for repairs. Also, the RB-36 sampler controller aircraft turned up some communications failures which needed correcting before operations started. By mid-December 1953, the USS ESTES had undergone work in San Diego and was ready for another test. General Estes, therefore, sent six F-84 samplers to San Diego to run a communications check and to give the pilots some additional practice on ground control interception. During this test, communications equipment worked satisfactorily aboard the ESTES.[19]

The value of a lead vest to protect pilots from radiation was demonstrated during Operation IVY. In August 1953, pilots of the sampler squadron worked out a new design for the vest. This consisted of a nylon, sleeveless vest which buttoned around the neck with fiberglass-lead shielding attached by four buttons. The fiberglass with lead woven into it was a quilted pattern and pliable. When the first copy of the new design arrived at Kirtland Air Force Base, the 4926th pilots took it to the swimming pool for safety tests. Escape from the vest, while in water, was found satisfactory. Dr. Plank suggested that the fiberglass-lead shielding be widened a bit to protect better and with this modification the vest weighed six pounds. The vest was manufactured for use during CASTLE.

Further precautions found the seats of the F-84G samplers covered with sheets of lead.[20] In addition, the pressurization system of the aircraft contained filters to keep out radiation. Yet more precautions were taken. When the sampler pilot flew into the atomic cloud, he went on 100 per cent oxygen and remained on this for the duration of the mission. When the sampler pilot landed, a platform mounted on a fork lift removed the pilot, thus preventing him from coming into contact with the contaminated skin of the aircraft.[21]

Joint Task Force SEVEN limited personnel again to 3.9 roentgens exposure. Some personnel, conducting special experiments, had been exempted from this restriction and included were the cloud sampler pilots who were limited to 12 roentgens. This would allow the pilots to fly three or four missions. But pilots who were expecting to fly on future tests were restricted to 7.5 roentgens for CASTLE.[22]

Sampling CASTLE Shots

After the training program had been drastically delayed, General Estes arranged to have the sailing date of the aircraft carrier, USS BAIROKO, delayed so the pilots could have more time for this purpose. Scientific personnel opposed because the carrier was taking some aircraft to the islands which were required immediately. The advanced echelon of Task Group 7.4 arrived on Eniwetok 2 January 1954, and began preparing for the main party which arrived on 27 January. As noted above, the sampler people began an intensive flying program. Flights were made to check time schedules and communications. These were followed on 16 February 1954, with a full-scaled rehearsal of the Air Task Group units, and, 23 February 1954, with all participating units.[23]

CASTLE was to have seven shots, all producing energy yields in megaton ranges. However, one was cancelled and another changed so the series ended with six events.

Chart: Operation CASTLE Schedule at Bikini Atoll

Shot	Date	Type
BRAVO	1 March 1954	Surface
ROMEO	27 March 1954	Barge
KOON	7 April 1954	Surface
UNION	24 April 1954	Barge
YANKEE	5 May 1954	Barge
NECTAR	14 May 1954	Barge

During the first shot of CASTLE, operations personnel expected the highest yield would be 1[illegible] megatons. However, early results indicated that the device had produced an unexpected yield of about 15 megatons.[24] Following detonation, the sampler aircraft took off and flew toward the cloud, under the guidance of the USS ESTES which vectored the samplers to the RB-36 control aircraft, flying near the cloud. The RB-36 had an experienced and highly skilled crew of controllers aboard. Dr. Plank, Colonel Fackler, and Colonel Houghton were on hand to direct the samplers. In addition, Major Billy Burke, on temporary duty from the 4925th Test Group (Atomic), and Major Finis A. Mitchell, the 4926th Test Squadron (Sampling) munitions officer, were on the control aircraft. The experience of these people comprised more than 35 atomic detonations before Operation CASTLE. They studied the growth and formation of the cloud and gave the sampler pilots specific directions on what portion of the cloud to penetrate and how long to stay around.[25]

The cloud [redacted] reached gigantic proportions. The initial climb of the cloud was about 1,000 feet a second and, before the first minute, it was past 40,000 feet altitude. Within a few minutes the cloud had pushed through the tropopause and had reached altitudes of 120,000 to 150,000 feet. As the cloud passed through the tropopause it began to flatten out until its width was from 150 to 200 miles. The base of the mushroom extended down from 45,000 to 48,000 feet altitude. The stem of the cloud usually was 10 to 20 miles in diameter and, just after the detonation, extended down to the sea. Later, as the wind began to move the cloud away, the stem base was from 18,000 to 20,000 feet altitude and poured out muddy rain from one to two hours. There was severe turbulence in the stem and lower portions of the mushroom, caused by convective forces set up by the extreme changes in temperatures and the many tons of water and material picked up and carried into the cloud. This turbulence lasted for about two hours, and was combined with extremely high levels of radiation. Therefore, the samplers did not attempt to penetrate such a cloud for at least two hours.

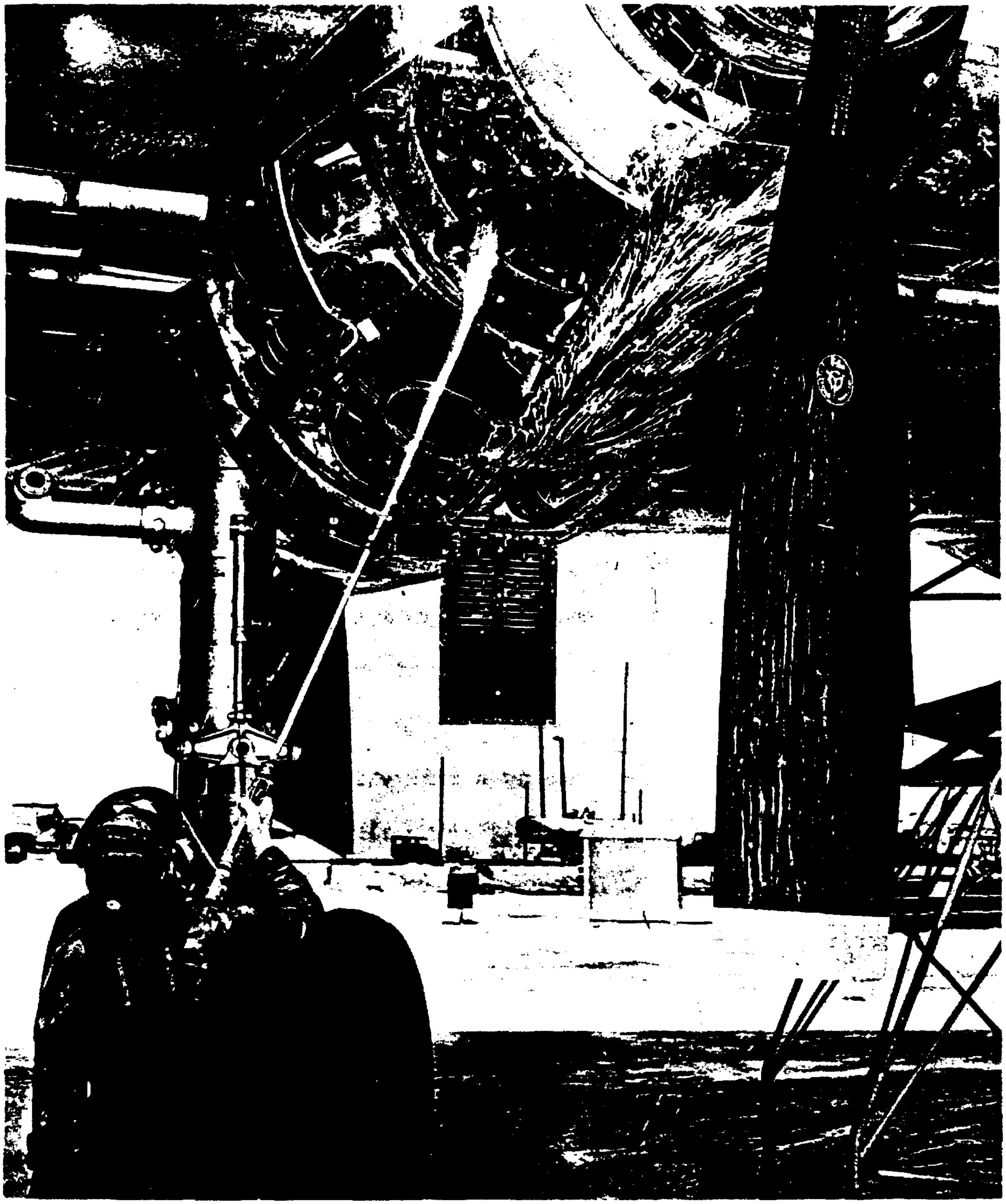
When the first sampler pilot made a pass at the cloud, he was directed by a quick route of escape in case radiation proved too hot. Normal sampling missions followed between three and one-half to five hours. The clouds, at the Pacific Proving Grounds, usually drifted to the northeast at a speed of about 30 knots, therefore, all sampling usually had to be accomplished within six hours after detonation, before the distance to the cloud got too great for the sampling aircraft to safely conduct their mission and get back to base.[26]

When the aircraft landed at Eniwetok, special crews of the 4926th Test Squadron removed the filter papers, installed them in lead containers, and placed them aboard long-range transport aircraft for the flight to the United States. The gas samples were transported to Perry Island.[27] Later on the Los Alamos Scientific Laboratory reported that these samples collected from BRAVO were the best taken from any detonation in the Pacific.[28]

The second shot, ROMEO, was postponed 17 times. This caused some trouble and changes in plans for the Test Aircraft Unit of Task Group 7.4, and others.[29] As delays piled up, General Estes informed General Mills that Task Group 7.4 might be overseas for a long time. "If we wait for the ideal winds desired," General Estes wrote, "we will have to wait for a typhoon and a fire on the back side of it. Seems to be only one typhoon comes every four years, so this may be a long TDY." [30]

Problems caused by the delays were serious, however, While waiting for the shots to be fired, aircraft suffered from drying up of seals in hydraulic lines, corrosion of metal surfaces, valves which stuck, and moisture corrosion of electrical surfaces. One way to prevent these troubles was to fly them, The Air Task Group "exercised" its aircraft and on one occasion it was discovered that two B-36 aircraft could not retract landing gears, while a number of F-84G aircraft would not feed fuel from their tip and pylon tanks because of stuck valves. To counteract the deterioration resulting from such idleness, General Estes reported to General Clarkson, task force commander, ". . . I am taking the risk of flying our aircraft frequently." General Estes was receiving the same weather briefings as General Clarkson. If the weather looked favorable for D and D + 1, General Estes instructed his aircraft to stay on the ground. If weather looked unfavorable for these two days, then Air Task Group commander assumed he was in D -3 day and instructed his commanders to fly their airplanes. In effect, General Estes was gambling that when the weather people believed a 48-hour delay in shooting was necessary, there was, in fact, at least 60 hours before the next shot. This allowed the aircrews necessary flight time to avoid many of the maintenance troubles. However, if an unforecast change in the weather caused the test directors to decide to fire a shot, General Estes admitted that he would be in "somewhat awkward situation." However, he added, "So far my guesses have been correct but the possibility of a miss always exists. . . In my estimation this is a risk which must be accepted if we are to be certain of having the truly critical aircraft in a position to complete the desired missions."

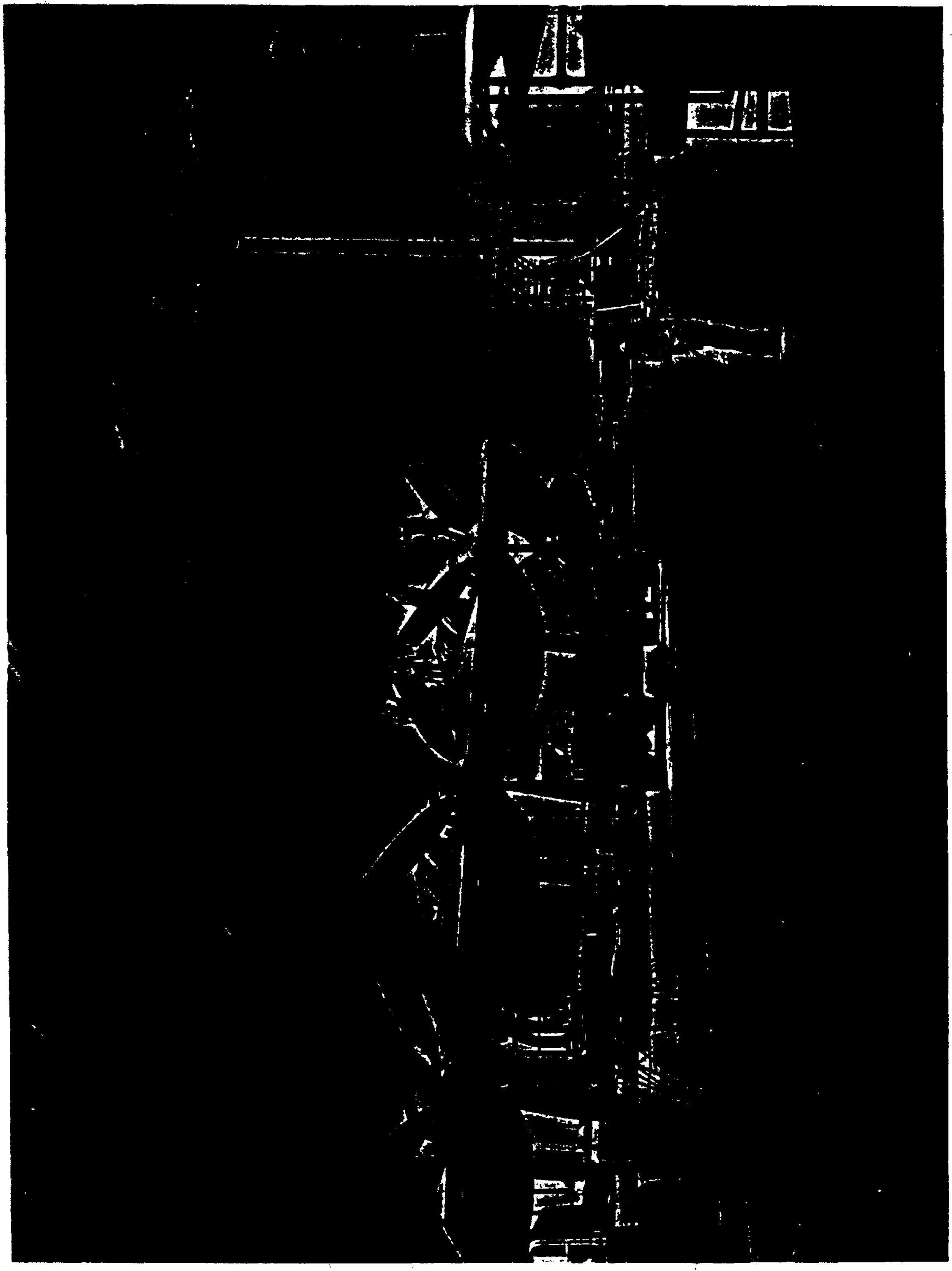
General Estes found that the B-36 sampler aircraft were in critical demand. Scientists were willing to fire a shot without F-84G samplers but not if the B-36 high altitude samplers could not perform their missions. The RB-36 control aircraft was also vital in that the F-84G samplers could not operate without it. Therefore, to meet these conditions, General Estes established a priority system for maintenance. First priority went to the two B-36 samplers and the RB-36 control aircraft, then F-84G samplers were second, along with the weather, rescue, the photographic



Decontaminating B-36 Sampler Aircraft, Operation CASTLE airplanes, and the C-47 inter-atoll airlift airplanes.[31] During the delays, General Estes also had his staff study the possibilities of getting Air Task Group aircraft ready for shots fired close in sequence. The limiting factor, General Estes learned, was decontaminating the huge B-36 bombers. If the CASTLE shots could be fired on a seven-day schedule, all aircraft could be ready. If the shots were five or six days apart, the Air Task Group could not put up 100 per cent of its aircraft but enough to support the shot. The staff worked out a 24-hour schedule for decontamination and maintenance and planned to try it out following ROMEO Shot.[32]

After twenty days delay, ROMEO fired on 27 March 1954. The yield was predicted [redacted] tons but its actual yield was about [redacted] Missions transpired without incident.[33] The group tried out its decontamination program and found that, with no undue trouble, personnel could ready half of the aircraft for another mission within three days. However, the maintenance priority system was not tried out because of the total number of aircraft which flew on ROMEO.[34]

KOON Shot occurred early on the morning of 7 April 1954. From an expected yield of [redacted] the device produced [redacted] which caused most of the effects aircraft to fail to gather data. The decontamination procedures were again applied and proved practical, however, the small yield delayed the maintenance priority system again. An F-84 sampler lost turbine buckets and made a forced landing on the Bikini airstrip. Only because the yield was much smaller



Decontaminating B-36 Sampler Aircraft, Operation CASTLE than expected did the pilot negotiate the landing safely. His wingman stuck with him through all this.

Results from the detonation of the KOON device eliminated the necessity for ECHO which was to follow. This had little effect on the Task Group 7.4 plans, except to lower the mission aircraft requirements a bit.

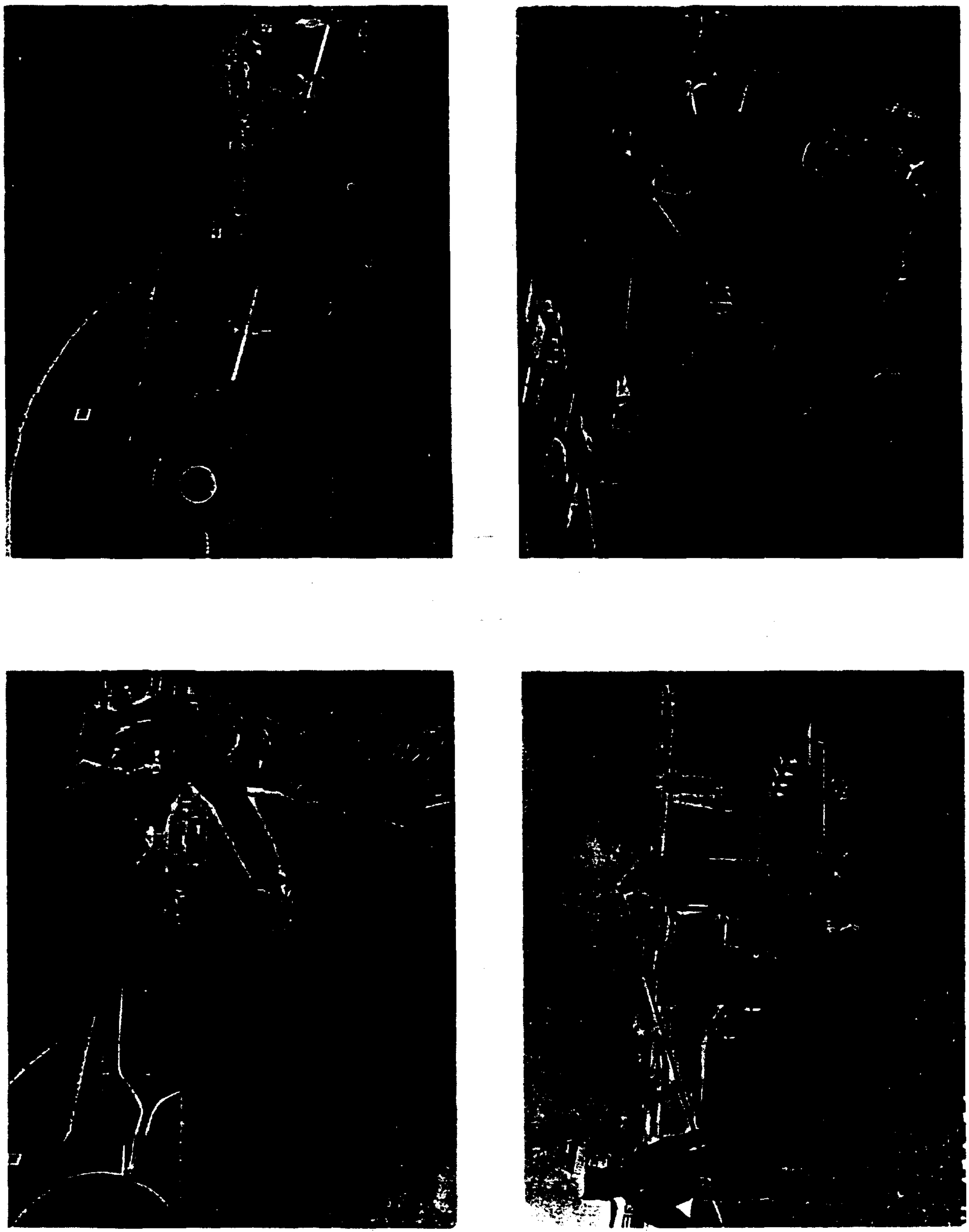
After five postponements, UNION followed on 26 April 1954. During the sampling operations, one F-84 sampler was replaced by a spare when his wing tank fuel system would not operate. Personnel decontaminated the one B-36 sampler and seven F-84 samplers, accomplished maintenance, and had these aircraft ready for another mission within 24 hours.[35]

YANKEE event fired on 5 May 1954 and the test director expressed the desire for another shot within 24 to 48 hours so the group used only half the aircraft. Two B-36 sampler aircraft flew into the cloud, each bringing back a double sample. There were also nine F-84 samplers on the mission.

Several postponements caused NECTAR Shot to be fired on 14 May 1954. On one occasion the shot was called off after all aircraft had taken off and were in position for zero hour. The detonation produced a yield of about 1.6 megatons and the samplers had trouble. A large concentration of cirrus clouds formed around the cloud and the control aircraft could find little to sample. A good many of the sampling aircraft arrived in the vicinity, as scheduled, orbited, waiting for a chance to penetrate the cloud, then were forced to return to base without samples. When they arrived at Eniwetok, the sampler pilots had to make landings in heavy rain. Many of the F-84 sampler aircraft had electrical trouble. In the rain, the approach to the runways at Eniwetok were always difficult. One F-84 sampler got down on the runway then hit a heavy puddle of water, veered off the runway and rammed into a sand bank. The nose wheel of the aircraft collapsed, but the sampler pilot escaped uninjured.[36] Damage was not really severe as the sand bank was about the height of the landing gear so that the nose gear was folded and the aircraft stopped in a level position with the main gear still extended and nose resting on the sand bank. The main problem was radiological control for when help arrived there were already two army privates sitting on the wing of the "hot" airplane. For this reason, an emergency landing on a strange airstrip was always of concern to the sampling people.

All six of the devices for Operation CASTLE were to produce yields in the megaton range. With the exception of KOON, with [redacted] expected, all the shots were larger. Perhaps, the most significant result of the operation was proof that [redacted] This eliminated the highly [redacted] then under way. The test series proved [redacted] weapons were practical and could be handled by operating units.[37]

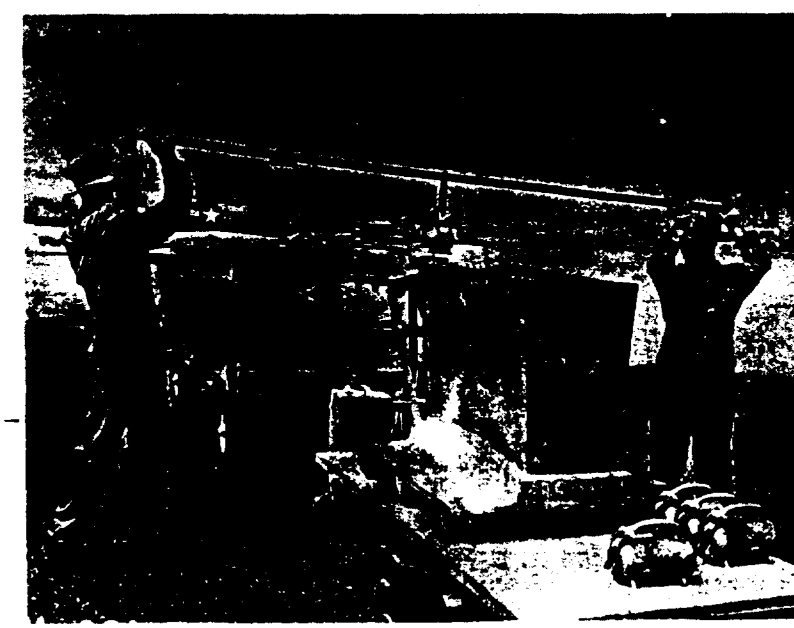
Colonel Houghton returned to the Air Force Special Weapons Center before the operation ended where he reported that samples had been from adequate to excellent, with some of them being the best ever taken. The F-84G samplers, operated to some 360 miles from Eniwetok, and returned to base within their fuel capabilities. The F-84G used wing tanks which



Preparing "hot" Samples for Delivery to the Laboratory, Operation CASTLE were dropped when empty. On two occasions the single place jets encountered minor trouble and landed on an emergency runway on Bikini Atoll. "The B-36 featherweight sampling," Colonel Houghton reported, "exceeded all expectations in terms of altitude attained and the usable in-cloud portion of their flight profile." The giant bombers took off with a weight of 230,000 pounds, climbed to a "reasonable altitude" and leveled off while the crew put on their S-4 partial pressure suits, then climbed to maximum altitude. This procedure usually required two hours and ten minutes. On many of the flights the bombers reached 55,000 feet. The crew encountered problems of keeping their jet engines running at the maximum altitude and on each mission lost one or two jet engines and started a gradual descent. They were able to remain at altitude for sampling approximately one hour and 40 minutes, and sampling equipment operated satisfactorily. "As usual, the personnel exposures were lower than anticipated prior to the operation," Colonel Houghton wrote. The reason for this was that fuel limitations did not allow the sampling aircraft to remain in the cloud as long as the scientific personnel from Los Alamos thought desirable during the planning phases of the operation. Sample quality was found to vary in the cloud with altitude and also with horizontal direction. Sample removal operations went off without trouble, pressurization system filters worked well, and the lead vests worn by the sampler pilots and crews reduced exposure to radiation by at least 40 per cent. No pilot complained about the vests being uncomfortable.[38]

Rolling Sample Paper for Insertion into Lead Pig, Operation CASTLE

Sampling Paper is Inserted into Lead Pig, Operation CASTLE



Lifting Loaded Pigs for Transfer to waiting Delivery Aircraft, Operation CASTLE

135

Operation CASTLE's sampling program resulted in the decision to ask for B-57 jet bombers as permanent sampling vehicles. Following the operation, General Estes recommended that the B-57 aircraft be used on all future sampling missions. He believed the aircraft would require a removable bomb bay fuel tank for additional range, reserve oil capability to take care of the rate of use of oil, "featherweighting" to increase the maximum altitude, and, finally, devices for collecting particulate and gas samples. Nine B-57B aircraft could replace fifteen F-84 aircraft, two B-36H samplers and one RB-36H sampler control aircraft. In addition, the nine B-57 aircraft could bring back better samples than could all these aircraft and would, of course, be much less expensive to operate. "Each aircraft would have a 'sampler director' aboard thus eliminating the need for a control aircraft." When more powerful engines were available, the B-57 aircraft would meet ". . . all future requirements in both continental and overseas tests in an effective, economical manner without the loan of aircraft from other USAF agencies," General Estes concluded.*[39]

---

*Central coordination of the efforts of the sampling aircraft is still necessary and a control plane has continued to be used with B-57 operations with a scientific director in the back seat. A B-57 is used, however, and can sample last as a back up in case of aborts. An exception to this took place during one of the ROVER sampling operations when the entire sampling runs were easily observed from the control trailer in the forward area. This was done because of the attempt to employ KDB-1 drones and control them from the ground. On this occasion the B-57 operations proceeded smoothly from the ground control, but this was a highly special case.

CHAPTER V

NOTES

1. MSgt. Max Gerster, The Special Weapons Center and Atomic Testing, AFSWC Hist. Div., Jan. 1957, p. 153, in Hist. Div. files, AFSWC Histories.

2. Hist. of TG 7.4 Participation in Operation CASTLE, 1 January 1953-26 June 1954, prep. by AFSWC Hist. Div., 8 Nov. 1954, pp. 9-10, in Hist. Div. files, Operation CASTLE.

3. Final Rpt. of the Cmdr., Air TG 7.4, Operation CASTLE, July 1953-June 1954, prep. by Brig. Gen. Howell M. Estes, Jr., Cmdr., TG 7.4, p. 10, in Hist. Div. files, Operation CASTLE, see App.

4. App. I to "Cloud Sampling Requirements for CASTLE," prep. by Hq., TG 7.1, JTG, LASL, 5 Feb. 1953; Memo. for Record, prep. by Lt. Col. R. S. Nugent, Admin. Asst. to D/Cmdr. TG 7.4, 18 Mar. 1953, subj.: Requirement Parameters for Alternate Sampling Vehicles - as set forth by Dr. Hal Plank, LASL, on 9 Mar. 1953, see App.

5. Ibid.; ltr., Lt. Col. Richard S. Nugent, Admin. Asst. to D/Cmdr., for O/S Tests, to Dep. Cmdr., for O/S Tests, AFSWC, 18 Mar. 1953, subj.: Use of Guided Drone and Rocket Vehicles for Cloud Sampling, see App.

6. Ltr., Brig. Gen. A. R. Walk, USA, CofS, JTF 7, to Cmdr., TG 7.1 and Cmdr., 7.4, 27 Mar. 1953, subj.: Guided Missiles for Cloud Sampling.

7. Ibid.; ltr., Col. Gavin to WADC, 9 Mar. 1953; ltr., Col. R. B. Gooch, WADC, to CG, AFSWC, 3 Apr. 1953, see App.

8. 1st Ind. (ltr., Brig. Gen. Walk to Cmdr., TG 7.1 and Cmdr., 7.4, 27 Mar. 1953), Col. E. M. Gavin, Dep. Cmdr., for O/S Tests, AFSWC, to Cmdr., JTF 7, 8 Apr. 1953, see App.

9. Ltr., Brig. Gen. H. M. Estes, Jr., Cmdr., TG 7.4, to Mr. D. C. Sewell, UCRL, 9 June 1954, subj.: Sampling with Guided Missiles, see App.

10. Ltr., Hq. WADC to CG, ARDC, 6 Mar. 1953, subj.: WADC Development of Atomic Cloud Sampling Devices; ltr., Hq. JTF-7 to Cmdr. TG 7.1 and Cmdr. TG 7.4, 27 Mar. 1953, subj.: Guided Missiles for Cloud Sampling; ltr., Dr. H. F. Plank, LASL, 18 Mar. 1953, subj.: Requirement Parameters for Alternate Sampling Vehicles - as set forth by Dr. H. F. Plank, LASL on 9 Mar. 1953; ltr., Lt. Col. Richard S. Nugent, to Dep. Cmdr. for O/S Tests, AFSWC, 18 Mar. 1953,

subj.: Use of Guided, Drone, and Rocket Vehicles for Cloud Sampling (R); 1st Ind., Hq., WADC, to CG, AFSWC, 31 Mar. 1953, subj.: Guided Missiles and Target Drone Performance Data; 1st Ind., Hq. AFSWC, to JTF-7, 8 Apr. 1953, subj.: Guided Missiles for Cloud Sampling; ltr., Hq., ARDC, to CG, AFSWC, 8 May 1953, subj.: WADC Development of Atomic Cloud Sampling Devices; ltr., Dr. Plank to Armand Kelly, LASL, 13 June 1951, n.s., (Proposal to Inyokern); ltr., U. S. Naval Ordnance Test Station, Inyokern, to Dr. Plank, 30 June 1952, n.s., see App.

11.. Final Rpt. of the Cmdr., Air TG 7.4, Operation CASTLE, pp. 11-12.

12. Ibid., 37-38.

13. Ibid., 38-39.

14. Ibid., 71

15. Ltr., Col. Gavin to Brig. Gen. Estes, 13 May 1953, n.s., see App.

16. Hist. of TG 7.4 Participation in Operation CASTLE, 38-40.

17. Officers' Roster, AFSWC, 15 Aug., 15 Sep., and 15 Oct. 1953, in Hist. Div. files, Statistical Records.

18. Hist. of TG 7.4 Participation in Operation CASTLE, 30-31.

19. Ibid.

20. Ibid., 24-25.

21. Ibid., 58.

22. Ibid., 57.

23. Ibid., 32-33.

24. Ibid., 62.

25. Ibid., 59-69.

26. Final Rpt. of the Cmdr., Air TG 7.4, Operation CASTLE, 9, see App.

27. Hist. of TG 7.4 Participation in Operation CASTLE, 59, 62.

28. Ltr., Dr. Plank to Brig. Gen. Estes, 11 Mar. 1954, subj.: BRAVO Sampling Mission, see App.

29. Hist. of TG 7.4 Participation in Operation CASTLE, 70-71.

30. Ltr., Maj. Gen. Mills to Brig. Gen. Estes, 24 Mar. 1954, n. subj., in Hist. Div. files, Operation CASTLE, General Estes Correspondence.

31. Hist. of TG 7.4 Participation in Operation CASTLE, 71-73.

32. Ibid.

33. Ibid., 70.

34. Ibid., 77-78.

35. Ibid., 76-78.

36. Ibid., 81, 84, 103.

37. Ibid., 85-106.

38. Ltr., Col. Karl H. Houghton, Actg. DCS/R&D, to Ch., Human Factors Div., Dir. of Rsch., ARDC, n. d., subj.: Activities Report, Operation CASTLE, see App.

39. Final Rpt., Cmdr., TG 7.4, Operation CASTLE, 11, see App.

CHAPTER VI

OPERATION TEAPOT: CONTINENTAL SAMPLING

Planning for Operation TEAPOT began early in November 1953 while preparations moved ahead for Operation CASTLE. In July 1954, the Air Force Special Weapons Center directed the 4925th Test Group (Atomic) to prepare itself for the operation and Colonel Harry L. Donicht organized a "semi-official" field test office to do the work. Colonel Donicht leaned heavily on Colonel Fackler's studies of Air Force nuclear test requirements. In November 1954, the Center issued a mission planning directive and indicated that Field Test Group 5 (Provisional) would be commanded by Colonel Donicht and would represent the Center during the test series.*

Sampling Preparations

By now, the Atomic Energy Commission considered cloud samples so important that without sampler aircraft the firing of a device was largely useless for test purposes. This information could be gathered from a study of the growth of the fireball or from study of measurements and multiplications of the neutrons produced by the explosion. However, these methods of calculating the yield usually gave an unreliably high value and were not favored.[1] The most accurate manner for determining what happened during the detonation was derived from radiochemical analysis of the fission and fusion products left in the cloud.

---

*Colonel Fackler was appointed the Air Operations Officer, making him the only Air Force Officer to hold a key position on every nuclear test operation since CROSSROADS in 1946.

Suitable samplers still remained a problem. In August 1954, Colonel G. W. Miller, Deputy Commander for Technical Operations at Baltimore, informed the Center that Air Force headquarters disapproved its request for B-57B sampler aircraft. Therefore, he directed, the B-57A should be thoroughly evaluated for that purpose. Two B-57A aircraft arrived at Kirtland Air Force Base in December, after having spent the same month in Baltimore for modifications. But, the 4926th did not have the two aircraft early enough to complete necessary modifications and maintenance. Partially for that reason, they sampled only four nuclear events during the operation.[2] Also, the original plan called for the B-57 aircraft to collect cloud samples from all TEAPOT detonations, however, a temporary grounding order prevented the aircraft from being used part of the time.[3]

Sampling Highlights

About five weeks into Operation TEAPOT, the first B-57A sampler flight followed detonation of the APPLE Shot on 29 March.

acting as sampler observer, piloted a B-57A into the cloud four hours after detonation and made a second pass seven minutes later. Although the airplane was not completely instrumented for sampling, mission results were adequate. The two officers first entered the cloud at 27,500 feet altitude, and during the two passes were inside the cloud 18 seconds.[4]

Eight days later, on 6 April 1955, a high altitude nuclear device was dropped from a Kirtland B-36 bomber. Four F-84G samplers and both of the B-57A airplanes were scheduled to collect samples, along with two

Atomic Cloud as Seen From Plane. Operation TEAPOT

B-36 airplanes. But the sampling mission got off to a bad start: three F-84G and one B-36 aircraft were unable to climb high enough to reach the nuclear cloud, thus, the cloud samples were collected by one F-84G and one B-36, and the two B-57A aircraft. The four aircraft found the cloud had scattered quickly and was impossible to identify.

piloted one B-57A with as the radiation operator. The other pilot was

served as radiation operator. Both airplanes made one pass into the cloud and returned to Indian Springs Air Force Base.[5] During MET Shot, in the observer's seat, made four nuclear cloud penetrations which kept the B-57A in the cloud for a total of 2 minutes and 40 seconds.[6] The last sampling mission for the B-57A aircraft was APPLE II, fired on 5 May. During this mission the airplane, piloted by with observing, was inside the cloud a total of 6 minutes.[7]

From these experiences, the Air Force Special Weapons Center constructed an evaluation of the B-57A as a sampler. Hal Plank from Los Alamos discussed performance of the B-57A airplane with the crews after each mission. Following HA Shot reported that because of the high altitude of the mission, he had to concentrate on flying duties at all times. A slight error handling the B-57A, for example, caused a loss of from 500 to 1,000 feet altitude and he was unable to keep the nuclear cloud in sight while maneuvering the airplane. Because the cloud scattered and stratified above 50,000 feet, there was difficulty in identifying for a sampling run. could not help because he was buried back in the fuselage of the airplane and had almost no visible contact with anything save the radiation instruments. Most of the samples collected, therefore, were probably taken in the "radiation flux" area outside or below the cloud. On the other hand flying 500 feet above gathered fairly adequate samples, but explained that as "a matter of luck" he happened to get a good view of the cloud just before penetration.[8] Although both crews received nearly the same radiation exposure, the latter's sample was far superior.[9] These discussions indicated that much of the performance

Chart: Operation TEAPOT Schedule *

Shot	Date	Type
WASP	18 February 1955	800 feet in air
MOTH	22 February 1955	300-foot tower
TESLA	1 March 1955	300-foot tower
TURK	7 March 1955	500-foot tower
HORNET	12 March 1955	300-foot tower
BEE	22 March 1955	500-foot tower
ESS	23 March 1955	67 feet underground
APPLE I	29 March 1955	500-foot tower
WASP PRIME	29 March 1955	739 feet in air
HA	6 April 1955	36,620 feet in air
POST	9 April 1955	300-foot tower
MET	15 April 1955	400-foot tower
APPLE II	5 May 1955	500-foot tower
ZUCCHINI	15 May 1955	500-foot tower

*See Appendix II for number of samples taken on each shot.

advantage of the B-57A was lost because of its poor visibility.

meanwhile, received orders to return to Kirtland. The Center had borrowed a "B" model of the B-57 and he along with Dr. Plank, as a passenger in the rear position, spent part of one afternoon "wringing out" the airplane. The "B" had several improvements over the "A" model but specifically a redesigned canopy which was similar to that of a T-33 jet trainer, affording unobstructed view for both crew members. With this canopy the pilot could maneuver at high altitudes while the radiation observer kept an eye on the nuclear cloud.[10]

Much of the sampling for TEAPOT had become fairly routine; however, occasionally the pilots of the 4926th Test Squadron (Sampling) reported minor malfunctions of equipment during a mission. On the fifth detonation, HORNET Shot, things were somewhat enlivened when F-84 pilots, maneuvering for a pass at the cloud, suddenly discovered two "extraneous F-86 type planes" coming toward them. They abandoned the pass, momentarily, to evade the unauthorized visitors.[11]

During WASP PRIME Shot, the B-50 sampler control aircraft remained in the air over five hours. Earlier in the morning APPLE I had fired and the controller did not land until after completing both missions. For the first time, sampler pilots had to fly two missions in one morning: after APPLE they landed, filter papers were replaced and they were off to sample WASP PRIME.[12]

During Operation TEAPOT, the Air Force Special Weapons Center carried off experiments of its own. A project, called "Contact Radiation Hazard Associated with Contaminated Aircraft," had as one of its goals a survey of evaluation of meters which were used to determine the actual radiation hazard to aircraft which penetrated a nuclear cloud. It was hoped, project personnel would be able to define exactly what dangers existed for crewmen working around a contaminated aircraft. Colonel Ernest A. Pinson and Captain Paul M. Crumley, project officers from the Research Directorate, planned to survey the gamma intensities from various parts of the aircraft and then compare the results with a survey of the contact intensities of beta plus gamma rays from mixed fission products distribution on the same section. From these studies they could determine accuracy of existing meters. Their instruments measured total dose radiation, depth, and rate.[13]

Aircraft usually were on the runway at Indian Springs Air Force Base within 15 minutes of the time they penetrated the cloud and the crew immediately began two hours intensive examination on the airplane and continued surveys for 24 hours. First inspections were accomplished with various ionization chamber-type meters with readings taken from one-fourth inch from the plane's surface, from three inches, one foot and, finally three feet. After meter inspection, personnel went over the same area with photographic film, film packets, which came into direct contact with the areas that contained particles of radioactive material, the packets being held in place by masking tape for the required exposure time. To record the general intensity of the area, the localized "hot spots" caused overexposure areas on the film. A second film exposure of much shorter duration followed for more accurate recordings of these spots. Through these methods the Research Directorate crews obtained successful radiation dose readings.[14] In other tests, swatches of glove material, with film strips, were exposed to contaminated surfaces. Also, to register radiation intensities received by the hands, personnel wore gloves with film strips inside and out. Yet another test, in which individuals rubbed their bare hands over contaminated areas, produced readings 30 per cent of the intensity found on the contaminated surfaces.[15] Altogether, the Center's survey group studied 17 airplanes with contamination readings that ranged from a density of 1 roentgen up to 14 roentgens. Five members of the survey team took part in all of the 17 surveys and no team member absorbed more radiation than the Atomic Energy Commission's tolerance limit of 3.9 roentgens.[16]

One phase of this study caught the attention of newspapers. To get information from an atomic cloud more quickly than that obtained by sampler aircraft, Research Directorate officers used several T-33 jet trainers and flew into the cloud much earlier.[17] One newspaper reported, "A group of dare devil Air Force scientists are making flights through the boiling reddish-brown atomic cloud in the interest of radiation research. . ."[18] An Albuquerque, New Mexico, newspaper ran the following headlines: "Inside of A-Cloud Colored Brick Red, Kirtland Scientists, Pilots Report."[19] However, the film badge experiments fascinated reporters.

PRIVACY ACT PROTECTED

MATERIAL REMOVED

SWEH-2-0034

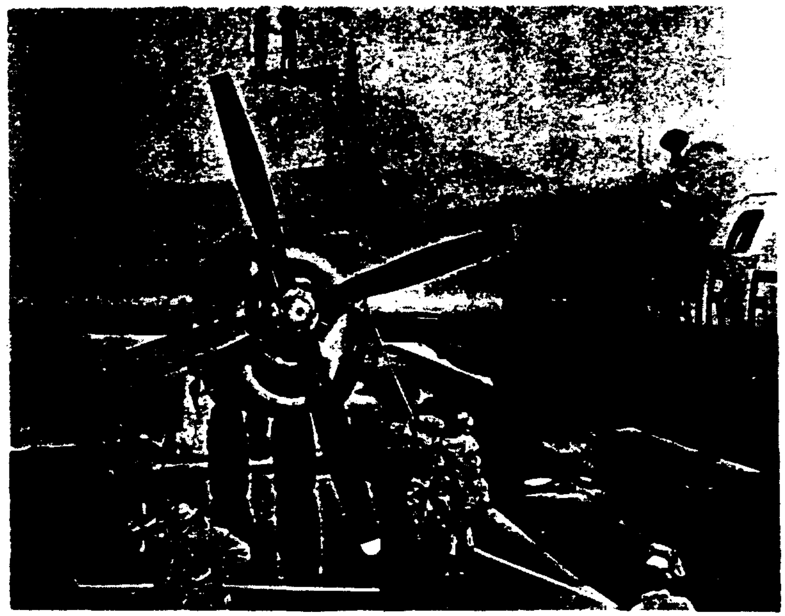
AFWL/HO

However, the pilots and the two observers were not concerned about their exploits. "We know what we are doing and there is nothing to get excited about."[20]

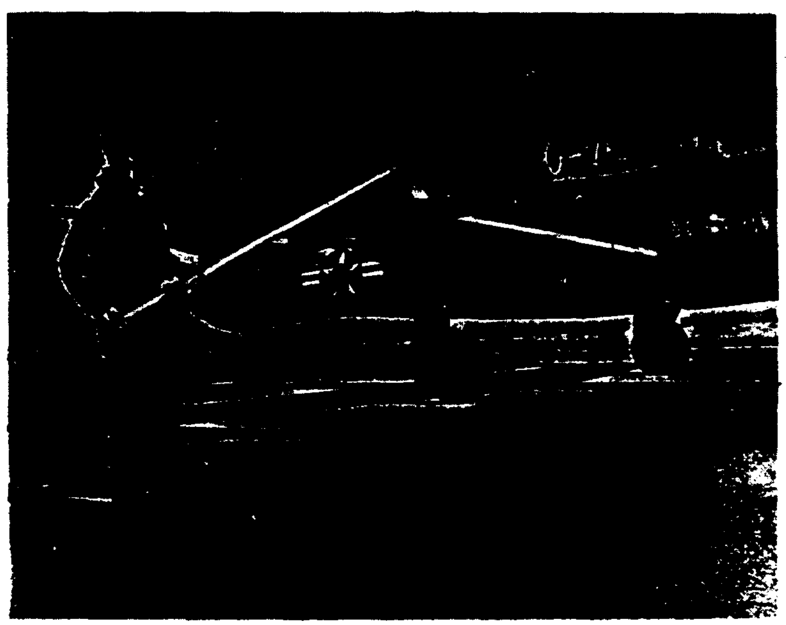
Drawing conclusions from its project, the Center's survey group pointed out that the contamination density readings occurred when instruments and film were placed in direct contact with the contaminated skin of an airplane for extended periods of time. Airmen servicing an aircraft, however, would probably keep their hands in more or less constant motion during the operation and would not likely receive as much radiation as was recorded on the meters and film badges. For a person to receive radiation of the same values as those collected during the survey, the project officers reported that an individual would have to come into direct contact with the nose of the airplane or the leading edge of a wing. In addition, the direct contact with the surface would have to be somewhat prolonged, depending upon the intensity of the particles touched to achieve a radiation burn.[21]

The High Altitude Nuclear Shot

When the high altitude explosion was detonated on the morning of 6 April 1955, it represented the culmination of about 18 months of intensive preparation at the Air Force Special Weapons Center. Early in October 1953, the Armed Forces Special Weapons Project was interested in a nuclear warhead for antiaircraft rockets. That agency, therefore,



Decontaminating The B-29, Operation TEAPOT



Airman Thomas O. Summers, 4926th Test Squadron (Sampling), demonstrates removal of a filter from the wing tip of an F-84 sampler, Operation TEAPOT

Soaping a B-57A Sampler Aircraft, Operation TEAPOT

recommended to the military services that a high altitude nuclear detonation be fired to gather air defense information.[22] On 27 November 1953, the Center received directions to determine the feasibility of dropping a two-kiloton warhead to about 40,000 feet altitude. After some preliminary tests, the 4925th Test Group decided that such a nuclear drop could be accomplished.[23] Then on 5 May 1954, the Center established a high altitude project for TEAPOT. To start with, the 4925th mounted a 3,000-pound practice unit in a B-36.[24] Then on 28 June 1954, the Center informed the 4925th of some additional requirements. The explosion was to be as high as possible, the only limit being the safety of the drop aircraft and crew. In addition, the device was changed from 3,000-pound unit to one of 1,500-pounds.[25]

Preparing the B-36 constituted a major portion of the work. In June 1954, the Field Command, Armed Forces Special Weapons Project, outlined detailed requirements. Just after releasing the nuclear device, the B-36 airplane was to drop canisters to record pressure and nuclear radiation data. Time zero equipment, used for previous nuclear tests, was to be installed, and Naval Radiological Defense Laboratory thermal radiation measurement equipment was to be mounted in the tail of the aircraft. Communications would be available in the aircraft for controlling the smoke-laying aircraft, and finally, Field Command asked that sampling equipment be mounted on the drop airplane so that, after dropping the nuclear device and the canisters, it could turn around and gather samples from the cloud.[26] However, it appeared to Center officials that operating at such a high altitude, the B-36 would not have enough fuel to remain long enough after detonation to gather samples.[27]

Dropping the canisters after the nuclear device presented difficult timing problems because they had to be spaced accurately and at the correct altitude when the detonation occurred. There was no available intervalometer which had the accuracy of release pulses. Mr. Samuel Schwartz, of the 4925th Test Group (Atomic), took on the job of designing an intervalometer with the required close tolerance. His device was installed on 26 August 1954, and then tested successfully. The Cambridge Research Center, in charge of instrumenting the canisters, later approved the intervalometer and the instrument assumed a key role in drop aircraft equipment.[28] The 4925th also installed calorimeters to gather radiation statistics for the Navy and other instruments were installed for the Cambridge Research

Center's canisters during the mission.

On 6 April 1955, the B-36 airplane again took off from Indian Springs Air Force Base and started climbing to 48,000 feet altitude -- the mean relative density ratio being below 1.06. As usual, one engine went out and the bombing crew announced the altitude change to 46,000 feet. The high altitude detonation went off with an orange-white metallic flash, reported to be brighter than the sun. The usual mushroom cloud was missing; instead, a hugh billowy circle, as if a giant had blown a gigantic smoke ring. Within a very short time the cloud thinned out and became invisible as the 4926th Test Squadron (Sampling) pilots could testify because of their difficulty in collecting samples. In spite of some difficulty climbing high enough, 4926th pilots who sampled the cloud, were successful, especially, those who sampled long after the shot.

On 21 December 1954, Air Force headquarters asked that airplanes obtain samples from the high altitude nuclear shots ". . . at an approximate range of 2,000 nautical miles east of the NPG [Nevada Proving Ground] at an altitude of 40,000 feet."[29] The 4926th Test Squadron sent two F-84G samplers, with one C-47 for support, to Andrews Air Force Base, Maryland, because weather conditions indicated that the nuclear cloud would drift east, passing over Nashville and Knoxville, Tennessee, Raleigh, North Carolina, and would go out to sea somewhere between Norfolk, Virginia, and Myrtle Beach, South Carolina.[30]

The two F-84G samplers flew six sorties while accomplishing the long-range sampling mission. One of the airplanes flew at 40,000 feet altitude and the other flew at 45,000 feet altitude. The samples

4926th Test Squadron pilots in front of B-57 Sampler, Operation TEAPOT colleoted ". . . were measured to be .6mr/hr/paper on the 40,000 feet sampler and .7mr/hr/paper on the 45,000 feet sampler. The papers were measured by folding four ways, at the surface of the envelope." Results of the mission were telephoned to Washington and another flight plotted. The last flight of the mission was made from Andrews Air Force Base, south along the coast to Myrtle Beach and then back to Andrews. The airplanes flew at 40,000 and 43,000 feet altitude. Each paper collected read approximately 0.2 milliroentgens. The 4926th Test Squadron (Sampling) reported: "In view of the fact that .1mr/hr/paper was considered a satisfactory sample the mission was considered a success."[31]

CHAPTER VI

NOTES

1. Rpt., "Minutes of the 93rd Meeting," 1 June 1955, Pt. II, p. 51, prep. by Sp. Wpns. Dev. Bd., in Tech. Info. and Intel. Lib.

2. Rpt., "Operation TEAPOT," Aug. 1955, p. 17, prep. by Stat. Serv. Div., DCS/C, in Hist. Div. files; interview with Maj. J. T. Corn, 26 Aug. 1955, see App.

3. Interview with Maj. A. G. Kearns, 4926th Test Sq. (S), 19 Sep. 1955.

4. Rpt., "Operational Summary Report, TEAPOT, Spring 1955," prep.by Col. P. H. Fackler, Dep. Cmdr., Fld. Test Gp. No. 5 (Prov.), Annex K, App. 1, in Hist. Div. files, Operation TEAPOT.

5. Ibid., Annex M, App. 2.

6. Ibid., Annex O, App. 1.

7. Ibid., Annex P, App. 1.

8. Ltr., Dr. H. F. Plank, LASL, to Col. H. D. Mahon, DCS/O, 14 Apr. 1955, n. s., in Jt. Fld. Ops, Br., DCS/O files.

9. Ltr., Col. Mahon to Cmdr., ARDC, 18 Apr. 1955, subj.: Evaluation of A & B Model of B-57 Aircraft for Sampling Missions, in Jt. Fld. Ops, Br., DCS/O files.

10. Interview with Maj. Corn, 26 Aug. 1955, see App.

11. Rpt., "HORNET", n. d., prep. by Nuclear Applications Br., 4926th Test Sq. (S), see 4926th Test Sq., (S), in Hist. Div. files.

12. Rpt., "WASP PRIME," n. d., prep. by Nuclear Applications Br., 4926th Test Sq. (S), see 4926th Test Sq.(S), Hist.Div. files

13. Rpt., "Operation TEAPOT Preliminary Report," Project 2.8a, May 1955, prep. by Capt. P. M. Crumley, et al., Rsch. Dir., in Tech. Info. and Intel. Lib.

14. Ibid., 20-21.

15. Ibid., 34.

16. Ibid., 23.

17. Ibid., 20-21.

18. Las Vegas Sun, 27 April 1955.

19. Albuquerque Tribune, 27 April 1955.

20. Las Vegas, Nev., Review-Journal, 28 April 1955.

21. Rpt., "Operation TEAPOT Preliminary Report," Project 2.8a, 35.

22. Rpt., "Summary Report of the Technical Director, Program 1-9," June 1955, prep. by FC/AFSWP, 15, in Tech. Info. and Intel. Lib.

23. Ltr., Col. H. H. Eichel, Dep. Cmdr., 4925th Test Gp.(A), to Cmdr., AFSWC, 23 June 1955, subj.: Operational Summary Report, Project SWOTO 54-34, "High Altitude Detonation Test Program," in Tech. Info. and Intel. Lib.

24. Ibid.

25. Interview with Capt. S. L. Bartalsky, 4929th Test Sq. (Dev.), 2 Sep. 1955. Captain Bartalsky was the weaponeer on the HA Shot.

26. Ltr., Col. P. T. Preuss, Dir. Wpns. Effects Tests, FC/AFSWP, to Cmdr., AFSWC, 29 June 1954, subj.: Support Requirements, B-36 Drop Aircraft, Operation TEAPOT, see App.

27. 1st Ind. (Ltr., Col C. A. Ousley, Test and Eval. Div., DCS/O, to Cmdr., Test Wing (Atomic) Prov., 12 July 1954, subj.: High Altitude Detonation, Operation TEAPOT) Lt. Col. M. A. Goddard, Adj., Test Wing (Atomic) Prov., to Cmdr., AFSWC, 24 Aug. 1954, see App.

28. Interview with Capt. Bartalsky, 2 Sep. 1955.

29. TWX, SWOT 3480, Hq., USAF (AFOAT-1) to Cmdr., ARDC and Cmdr., AFSWC, 21 Dec. 1954, see App.

30. Rpt., "HA", n. d., prep. by Nuclear Applications Br., 4926th Test Sq. (S), in Hist. Div. files, Operation TEAPOT.

31. Ibid.

CHAPTER VII

OVERSEAS FOR OPERATION REDWING

At a REDWING conference staged by Joint Task Force Seven in Washington, D. C., on 29 April 1955, officials agreed on six B-57B aircraft.[1] The 4926th Test Squadron (Sampling) still had no B-57B aircraft and had to borrow them from the Tactical Air Command.[2]

Plans and Operations

Planning officers and scientists were not entirely satisfied with the sampling platforms used, or the number provided. In reply to a letter from Lieutenant Colonel Richard J. Hynes, Acting Director of Operations for the 4950th Test Group (Nuclear), Dr. Harold F. Plank discussed the possibility of obtaining two samples with one plane. He pointed out that mission time requirements were miltiplied by four to obtain two samples as opposed to one and that obtaining two samples was possible early in the sampling operation or if sample size was small. In any case, sampling could be conducted under conditions unsuitable for F-84C aircraft if a full compliment of B-57 aircraft were not available for use by the cloud samplers.[3]

With each additional nuclear testing operations, broader experience proved invaluable. The Los Alamos Scientific Laboratory submitted a detailed analysis of requirements to Commander, Task Group 7.4. Making no reference to past difficulties between operating organizations of tests, the document listed, besides requirements, concepts, aircraft control, radiation exposure requirements, aircraft contamination and return exposures, pre-mission preparations, post-mission treatments, conduct of Air Force support personnel, sampler support teams, and the Air Force equipment necessary to support special activities and what equipment would be supplied by the laboratory. Every conceivable facet of the proposed operation was covered and designed to eliminate any misunderstandings after Operation REDWING started.[4] To avoid radiation burn accidents, Dr. Plank included instructions to be used in installing, removing, and securing filter papers. He described the exact tools to be used for each operation, the placement of the tools on the tractor-trailer combinations used during sample handling, and precise steps to be taken for all filter paper handling. Although at the outset, only trained physicists were permitted to handle filter paper samples, this duty became one of many assigned to personnel of the 4926th Test Squadron (Sampling).

Within the 4926th, the Test Aircraft Unit had command operational control over all elements in the test area.[5] Additional responsibilities included:

(1) Provide trained personnel for all ground radiological monitoring of the airfield at Eniwetok.

(2) Provide trained personnel to accomplish and supervise the removal of particulate cloud samples (collected by aircraft) for Los Alamos Scientific Laboratory and the University of California Radiation Laboratory.

(3) Procure, issue, and maintain all radiac and protective equipment required for Task Group 7.4 operations.

(4) Establish and operate aircraft, equipment, and personnel decontamination centers.

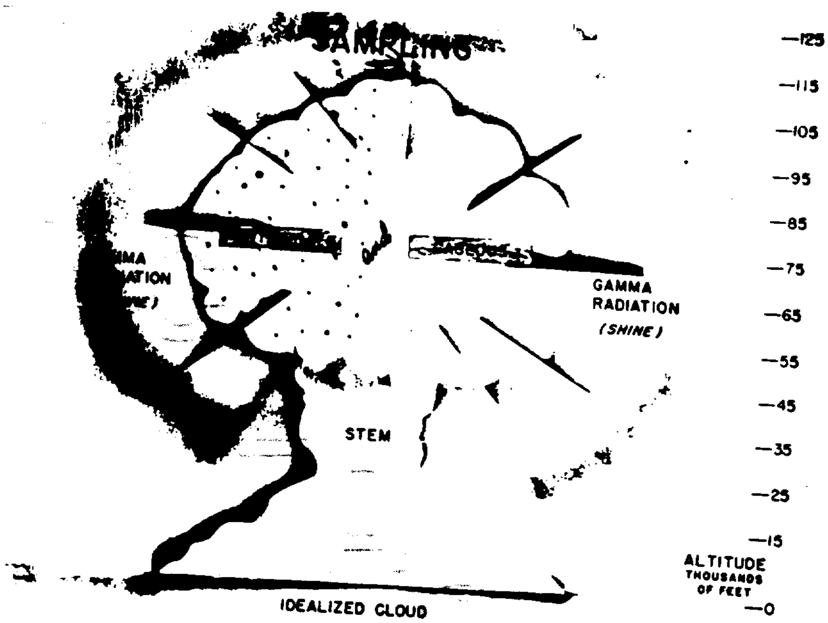
(5) Arrange for the acquisition, issue, and control of all film badges for personnel of Task Group 7.4 participating in this operation.

(6) Establish a suitable program to train Task Group 7.4 and 7.1 project personnel as radiological monitors. This course was given at Eniwetok prior to the first shot.

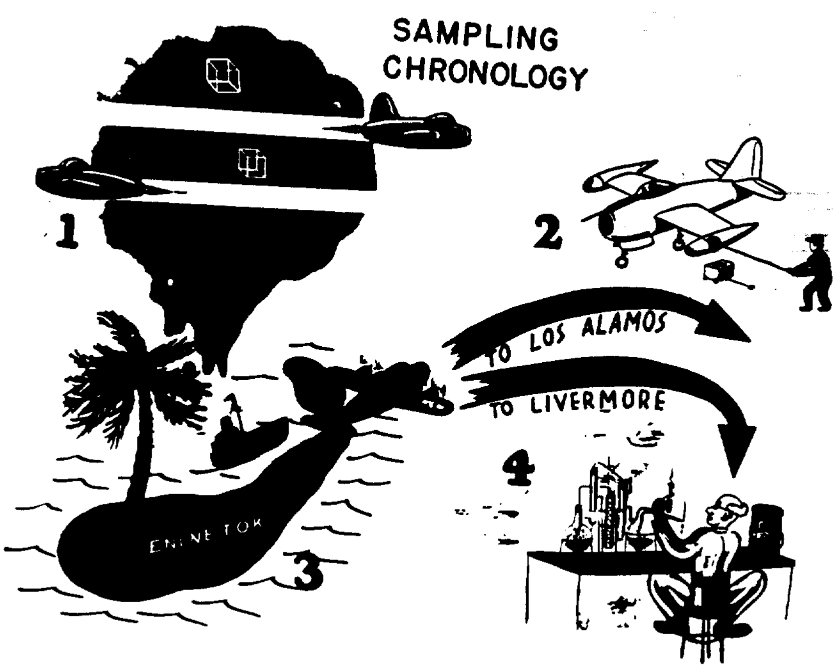
Along with normal functional sections, the 4926th maintained a nuclear applications section to instrument and prepare aircraft for nuclear cloud sampling. It was also responsible for removing the cloud samples from aircraft and preparing them for shipment. Finally, the nuclear applications section operated aircraft decontamination and personal dosimetry facilities.

Successful accomplishment of the sampling phases of Operation REDWING, approaching in August 1955, still depended on obtaining modified aircraft of the proper types and numbers. At the operational planning conference, noted above, delegates were notified that the requirements for a B-36 sampler controller, previously included on requirements lists for REDWING, were deleted. The 4925th Test Group had at least ten F-84 aircraft for sampling duties to augment the B-57 aircraft, and officials had expected no difficulty acquiring these aircraft for REDWING.

On 1 September 1955, Colonel Carl A. Ousley, then commander of the 4926th, visited Warner-Robins Air Materiel Area, where the B-57B modifications were being performed, for a firm delivery date and to investigate expediting the modifications. He learned that three of the aircraft were to be completed in November and three in December, but a subsequent technical order required additional modification on the



GAMMA RADIATION (SHINE)
STEM
IDEALIZED CLOUD
ALTITUDE THOUSANDS OF FEET
125
115
105
95
85
75
65
55
45
35
25
15
0



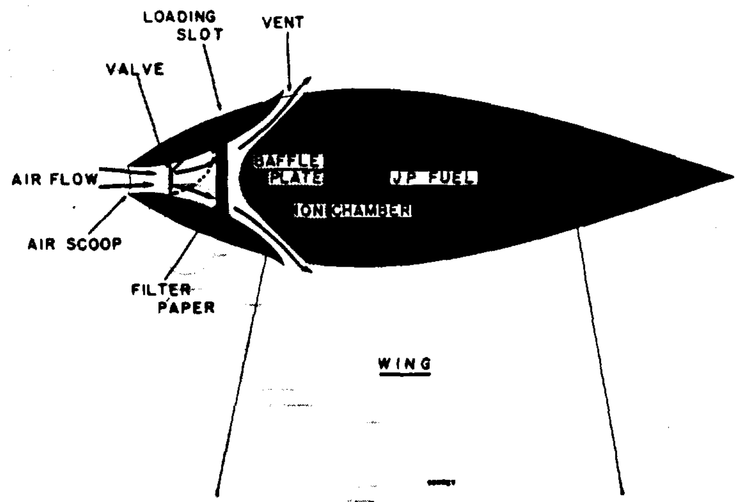
SAMPLING CHRONOLOGY
1
2
TO LOS ALAMOS
TO LIVERMORE
3
4

aircraft and none could be expected before December. Such delays in delivery dangerously shortened the time available for training. Late in November, Colonel John S. Samuel, Task Group Commander, personally visited Warner-Robins and managed to get two of the aircraft released immediately, a third was released that same month, and a fourth in December. Crew training continued through a successful conclusion by applying round-the-clock schedules. The remaining two B-57D aircraft arrived at Kirtland in January 1956.[6]

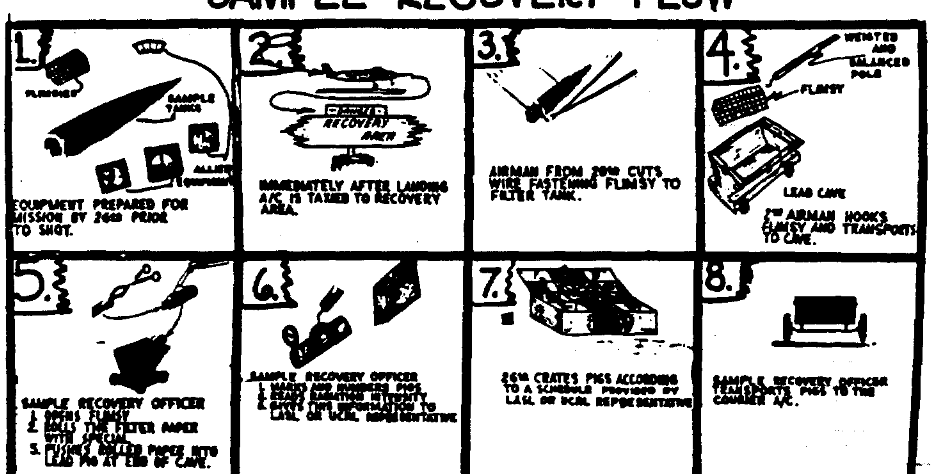
A major assignment for the 4926th Test Squadron during REDWING was to determine the effects of high yield, nuclear clouds on various types of aircraft, preferably from 30 to 150 minutes after detonation. Previously, data had been inconsistent, therefore, investigations of early penetrations would be pursued cautiously in face of unknown quantities of radiation and turbulence.[7]

Strategic Air Command leaders requested data on blast and radiation levels in nuclear clouds from 30,000 to 50,000-foot altitudes but could offer neither the airframes nor the crews. Tactical Air Command was requested to assist and initially agreed to accomplish the required twenty penetrations, four for each major detonation.[8] In September, Headquarters, United States Air Force, tried to obtain a commitment from the Tactical Air Command for six aircraft for three and one-half months, with crews and maintenance personnel without hindrance to its combat readiness program. Tactical Air Command agreed, formally, to furnish three such aircraft and crews, but only for three months. REDWING leaders could not accomplish the sampling mission on that basis so bargained for

DIAGRAM OF WING-TIP FILTERING SYSTEM



SAMPLE RECOVERY FLOW



9. ESSENTIALLY THE SAME PROCESS WILL BE FOLLOWED BY THE 26TH IN THE PREPARATION OF AFOAT-1'S GAS SAMPLES, EXCEPT THAT THE SAMPLES ARE ALREADY BOTTLED AND MUST ONLY BE BOXED AND CARRIED TO THE COURIER.

five B-57B aircraft for a period of four months or four aircraft and crews for five months.[9]

In November 1955, Colonel Samuel was called to a conference held at Air Force headquarters and stated his needs so successfully that Tactical Air Command was directed to furnish five B-57B aircraft, 21 pilots and navigators, together with the necessary support personnel. Thereupon, that command delegated the 405th Bomb Wing to furnish two aircraft and to hold a spare in readiness, and the 461st Bomb Wing to furnish three aircraft.[10] Instrumentation and modification of the above aircraft terminated in February 1956, and the aircraft and crews arrived at the proving ground in April.

Shots and Aircraft Participation

During August 1955, additional sampling requirements appeared in Program 6.3, consisting of ionospheric studies designed to measure the effects of nuclear discharge on the ionosphere and with assistance to a secondary project (ultrasonics) in observing and recording signals emanating from nuclear detonations at ever increasing distances from ground zero so as to determine the maximum distance at which these signals might be discerned and recorded. The Cambridge Research Center furnished an instrumented C-97 aircraft with its crew for the purpose.[11]

Throughout Operation REDWING, perhaps the greatest single source of trouble in achieving the smoothest of operations was the inability of controller communications center to maintain clear contact with airborne crews. Failures of all types of communication equipment continued throughout the test series and a considerable number of remedies were attempted on the spot.* These failures lowered the efficiency of sampling crews; some managed through visual guidance; others aborted when ground control failed at critical times.[12]

Flying safety records for the squadron were at its usual high standards. Although a landing incident removed a B-57B from operational status from 29 March 1955 until 22 May of that year, its absence from the sampling force did not adversely effect the sampling mission.[13] The most serious aircraft accident during REDWING involved a sampling B-57B. For on 18 May 1955, the pilot of the B-57B, in climbing to 26,000 feet to avoid rain clouds, felt a heavy explosion and blinding flash within his craft. Both fire warning lights immediately flashed and the pilot instructed his observer to eject. Rough seas delayed the rescue of the pilot for some four hours;

LACROSSE. The shot schedule for REDWING was changed in late April to provide for firing LACROSSE on 29 April and CHEROKEE on 8 May. After two cancellations, LACROSSE finally detonated at 0625 hours, 5 May.[15] Although 20 aircraft originally were scheduled to take part, 25 finally composed the array but in the end the B-66 aborted. Added to the final array were a B-57, a B-57 sampler, a B-57, and three P2V's. In all,

*Detailed discussion of the problems which arose and steps recommended during later tests can be found in the Final Report, Operation REDWING, by Task Group 7.4 Commander.

sampling comprised one B-57 and six F-84G aircraft and two B-57 control planes. Through MSQ-1A radar, officials positioned the four effects aircraft with only minor errors.

CHEROKEE. After several postponements because of weather conditions, a B-52 dropped a large-yield weapon for CHEROKEE Shot. All aircraft had azimuthal errors and horizontal range far different from those planned because of the aiming and timing errors in dropping the device. Much of the data obtained resulted from aircraft positioning procedures which were initiated upon realization that the countdown had become erratic. According to the mission description, 42 aircraft were scheduled to participate including the drop B-52 and the canister drop B-36. Only 38 aircraft took part but the aborts were not samplers. Three B-57 and six F-84G with 1 control B-57 made up the sampling effort.

ZUNI and YUMA. On 28 May, dual shots occurred for the first time in weapon testing: ZUNI on Bikini Atoll and YUMA at Eniwetok. Fifty aircraft were scheduled for the dual event, 11 for YUMA and 39 for ZUNI. No B-57 samplers participated in the former, but six F-84G took samples with one B-57 control aircraft. For the ZUNI Shot there were four B-57 samplers and two F-84G with one B-57 control aircraft. ZUNI went first.

ERIE. On 31 May, this shot occurred on a 300-foot tower on Eniwetok Atoll. H-hour was 0615:30. Seventeen aircraft participated under the control of the Air Operations Center without incident. Of these, one B-57 and six F-84G aircraft were samplers under one B-57 control.

SEMINOLE. The sixth shot occurred at 1255:30 hours on 6 June at

Eniwetok. Fifteen aircraft participated altogether with one B-57, six F-84G samplers, and controller.

FLATHEAD and BLACKFOOT. This dual shot occurred on 12 June at 0626. Schedules underwent numerous changes for several days previous but, finally 33 aircraft participated in FLATHEAD and 9 for BLACKFOOT. Of these, 4 were B-57 samplers for FLATHEAD, and 6 F-84 aircraft sampled BLACKFOOT with 2 B-57 control planes. All aircraft performed well except a B-52 which aborted because of radar malfunction.

KICKAPOO. On 14 June, a [redacted] device fired at Eniwetok at 1126 hours. Eleven aircraft were scheduled including six F-84 samplers, one B-57 controller, and all performed without trouble.

OSAGE. This device was the second airdrop of the series and occurred from a B-36 aircraft on 16 June, 1314 hours. Altogether, twelve aircraft took part, six F-84 samplers and a B-57 control aircraft.

INCA. On 22 June, INCA detonated at Eniwetok, 0956 hours. This shot was another [redacted] with twelve aircraft participating. Again the six F-84 samplers operated successfully.

DAKOTA. DAKOTA Shot followed on 26 June at 0606 hours at Bikini Atoll. It was to have been a dual shot with INCA originally but weather had prohibited this. Thirty-four aircraft were scheduled but one Navy effects plane cancelled. Four B-57 and four F-84 aircraft sampled the shot with one B-57 controller on hand.

MOHAWK. [redacted] MOHAWK detonated on a 300-foot tower at Eniwetok Atoll, 3 July at 0606 hours. Twenty-eight aircraft participated though weather was worse than usual with huge cloud build-ups and heavy rain squalls. Five B-57 aircraft and five F-84G aircraft sampled again with one B-57 control aircraft.

APACHE. On 9 July at 0606 hours, a [redacted] device fired from a barge off Eniwetok. Thirty-five aircraft performed without difficulty including four B-57 and four F-84 samplers with one B-57 control plane.

NAVAJO. NAVAJO was a [redacted] device detonated on 11 July at 0556 hours, another barge shot at Bikini Atoll. Of the thirty-five aircraft performing as scheduled, four were B-57 and another four were F-84 samplers, plus controller.

TEWA. Another device fired from a barge at Bikini, TEWA was high-yield. It occurred on 21 July at 0546 hours. Twenty-four aircraft took part with four each of the B-57 and F-84 samplers. Again, pilots encountered no difficulties.

HURON. The last shot of the REDWING series detonated on 22 July at 0616 hours. Twenty-one aircraft performed without incident. They included three B-57 and four F-84 samplers with the B-57 control plane, as usual.*

On only two occasions during Operation REDWING did the radiological safety officers detect unusual fallout. Following the MOHAWK Shot, less than 50 milliroentgens per individual was indicated. Considerable fallout occurred after TEWA, however, generally over the Eniwetok lagoon and atoll areas. Officials performed constant monitoring of areas during the night

*See Appendix II for number of samples taken on each shot.

which indicated an average 80 milliroentgens each hour until 0330 hours the following morning when a rain increased the fallout to 100-110 milliroentgens the hour. Following the rain, the fallout reduced to safe levels. Immediate personnel were in protected positions so that no special clothing for safety precautions was necessary. However, the swimming area and lagoon were placed off limits until those waters reached a safe radioactive level.[16]

Radiation Safety and Monitoring

As an additional duty the Commander, 4926th Test Squadron (Sampling), found that he was faced with the task of training for radiation safety and monitoring. Initially, it was thought that the selected men could attend regular Air Force schools. Investigation disclosed that such classes would not coincide with the periods in which the 4926th men could attend. Time was lacking to organize and conduct special classes in the zone of interior for airborne monitors, weather island monitors, and monitors for Task Group 7.4 operational areas. Consequently, officials established a school at the proving grounds. Insufficient instructors, almost no visual or training aids and instruments, and the lack of classrooms on Eniwetok made conducting such a school difficult.[17] The Decontamination and Sampling Element of the 4926th Test Squadron conducted the school in two phases during April 1956. Subsequently, all personnel were issued film badges for measuring personal radiation dosages.

Rad Safe Personnel Boarding Plane, Operation REDWING

Flight Safety Test Area

To assure best possible arrangements for flight safety, Colonel Samuel instituted rigid training schedules and flight rules for all pilots operating in the test area. All pilots were indoctrinated and thoroughly trained in flight regulations and peculiarities of tropical and night flight. The Sea-Air Rescue Element consisted of four SA-16 aircraft for rescue activity, supplemented by the operation of two Air Force surface rescue vessels and an H-19B helicopter, along with mechanical devices such as runway barriers.[18]

The 4926th published definite policies and procedures for ground flow of aircraft, operation of motor vehicles in the landing and parking of aircraft areas, proper marking and lighting of obstructions, safe positioning of test array aircraft, and specific instructions for each element of all test operations. A task group operations officer coordinated with tower personnel all instructions from the air operations center.

Determining Aircraft Positioning Responsibility

Immediately rumors started circulating about a subsequent overseas series, officials of CASTLE began to advise possible successors for REDWING on better arrangements for aircraft positioning. Apparently few officials were satisfied with the split-responsibility for controlling aircraft as practiced in Operation CASTLE. An outspoken advocate for assigning the control responsibility in a military manner was Colonel Herschel D. Mahon, of the Air Force Special Weapons Center, who recommended to Colonel David O. Byars, Jr., Joint Task Force Seven, that the commander responsible for aircraft control should also be responsible for safe positioning. He recommended that the commander, Task Group 7.4, be held responsible for positioning.[19] On 27 May 1955, Brigadier General Howell M. Estes wrote to Brigadier General William M. Canterbury, Commander, Air Force Special Weapons Center: "Although it is none of my business . . . The second problem involves the interrelationships between the commander, Task Group 7.4 and the commander Task Group 7.1 in their mutual responsibility to the Commander, Joint Task Force for positioning of aircraft and particularly for positioning of the weapons effects test aircraft." He introduced some of the difficulties encountered in previous tests.[20] "However, it had one big difficulty in that the one individual was responsible to the Commander of each of these two task groups and consequently was never completely controlled by either." He also commented on the ineffectiveness of the officer responsible for positioning stating that he believed that the relative ineffectiveness of the man resulted from the fact that he was a Strategic Air Command officer and therefore "did not necessarily hold the full confidence of the positioning people in Task Group 7.1." General Estes intended to show that the arbitrary assignment of a Strategic Air Command officer resulted in the assignment of an officer to that responsibility who did not have the level of test experience enjoyed by officers of other available units. He also mentioned the everlasting changes in plans made by the "scientific element" and the difficulties created by those last minute changes.

"The basic difficulty in determining the optimum organization lies in the fact that the Commander, Joint Task Force, has in the past held the Commander of the Scientific and Air Task Groups jointly responsible for the positioning of the aircraft," General Estes advised. "He has required the Commanders of the Scientific Task Group to assure him that each aircraft will be in a position at the time of detonation which is safe from a scientific standpoint, and at the same time, has required the Commander of the Air Task Group to assure him that from an operational and aircrew standpoint these positions are safe."[21]

General Estes submitted two methods for solving the situation. Plan A assigned the entire responsibility for positioning of aircraft and the maintenance and operation all to the commander of the air task group. Plan B assigned joint responsibility through employment of a positioning board with chairman being the commander of the air task group with representation from the scientific group. But, the final responsibility remained with the air task group. General Estes then advised General Canterbury to seek a conference with representatives of all agencies concerned in order to resolve the differences of opinion.

Despite urgent recommendations, the issue was not settled by 1957.[22] In November 1956, General Canterbury alluded to the fact that "the language in the agreements and directives on the responsibilities of the air operational commander has been subject to considerable interpretation."[23] In turn, he outlined areas of responsibility which absolved the air commander of determining all subordinate details, such as each agency specified would provide the air commander with the data related to blast effects, overpressures, predicted yields and other factors from which the air commander could draw positioning decisions. By 25 January 1957, General Canterbury had apparently secured that approval for he sent a communication to all agencies delineating responsibilities for positioning aircraft.[24]

Headquarters, Air Defense Command, Commander, Joint Task Force SEVEN, and the Atomic Energy Commission, approved General Canterbury's recommendations without reservation.[25] Chief, Bureau of Aeronautics, United States Navy, concurred, reserving final approval of placement of Naval aircraft to that agency.[26]

CHAPTER VII

NOTES

1. Memo. for Record, prep. by Col. David O. Byars, Jr., Assist. CofS, J-3, U. S. Army, 29 Apr. 1955, subj.: Resume of Conference on Military Support Requirements, see App.

2. CHART: Aircraft Programmed for Participation in REDWING, as of 15 June 1955, undoubtedly prepared by members of the Task Group 7.4, AFSWC, see App., also, 144-145 this chapter.

3. Ltr., Dr. H. F. Plank, LASL, to Cmdr., 4950th TG (N), Attn.: Lt. Col. Richard J. Hynes, Actg. Dir. of Ops., 2 Nov, 1956, n.s., see App.

4. Ltr., Dr. H. F. Plank, LASL, to Cmdr., TG 7.4 (P), 15 Feb. 1956, n.s., see App.

5. Final Hist., TG 7.4, Operation REDWING, prep. by MSgt. William A. Evans, Historian, 4950th TG (N), Feb. 1957, p.85, in Hist. Div. files, Operation REDWING.

6. Ibid., 23, 85-90.

7. Ibid.

8. Ibid., 24.

9. See chapter dealing with B-57 procurement for further source material on this problem.

10. Final Hist., TG 7.4, Operation REDWING, op. cit., 26.

11. Ibid., 26-27.

12. Ibid., 120-122.

13. Ibid., 126-127.

14. Ibid., 128.

15. Greater discussion of events will be found in History of Air Force Special Weapons Center, 1 July - 31 December, 1956, 283-308.

16. Final Rpt., TG 7.4, Operation REDWING, op. cit., 129

17. Ibid., 69.

18. Ibid., 64-65.

19. Ltr., Col. Herschel D. Mahon, DCS/O, AFSWC, to Col. David O. Byars, Jr., JTF-7, n.d., subj.: Memorandum for the Record - The Responsibility for Control of Aircraft in the Pacific Proving Ground and Safe Positioning, see App.

20. Ltr., Brig. Gen. Howell M. Estes, Jr., to Brig. Gen. William M. Canterbury, Cmdr., AFSWC, 27 May 1955, subj.: WADC Participation in REDWING, see App.

21. Ibid.

22. Ltr., Lt. Col. Elea W. Bowen, Asst. CofS, DOD, to Dir. of R&D, Hq., USAF, Attn.: Col. D. I. Prickett, 10 Apr. 1957, subj.: Weapons Effects Tests Aircraft Positioning Committee, see App.; 1st ind., Col. B. R. Lawrence, Asst. Dir. of R&D, DCS/D, to Ch., AFSWP, 20 Jun. 1957, (ltr., Col. John S. Samuel, Cmdr., 4950th TG(N), to Cmdr., AFSWC, 13 Nov. 1956, subj.: Positioning Aircraft.) see App. "Although the responsibility for safe positioning of aircraft in atomic tests," Colonel Norair M. Lulejian, Chief, Nuclear Applications Division, Headquarters, Air Research and Development Command, wrote on 19 July 1957, "has not been definitely established, the inclosed correspondence is forwarded for your information." His letter was addressed to Commander, Wright Air Development Center.

The copies of correspondence which he included revealed the interservice struggle for positions of responsibility. Writing for the Chief, Armed Forces Special Weapons Project, Lieutenant Colonel Elea G. Bowen, stated, "It has been further established that the sole responsibility for the selection of the aircraft position and the safety of the position lies final responsibility for determining that the positioning of all participating aircraft was safe." This was made a matter of record in a document, dated 21 January 1955, "Aircraft Operations---TEAPOT," prepared by Donald G. Leehy, Manager, Santa Fe Operations Office. Subsequently, for Operation REDWING, although not spelled out in quite as much detail, the air operational commander (TG 7.4) was given the overall responsibility for the safe positioning of test and other aircraft (para 2d (25), CJTF SEVEN Planning Directive, Operation REDWING). This responsibility was restated in the JTF SEVEN operation plan.

23. Ltr., Brig. Gen. Canterbury, to Cmdr., ARDC, 13 Nov. 1956, subj.: Safe Positioning of Aircraft, see App.

24. Ltr., Brig. Gen. Canterbury, to Cmdr., ARDC, et al., 25 Jan. 1957, subj.: Positioning of Aircraft Supporting Nuclear Tests, see App.

25. Ibid.; 1st Ind., (ltr. Col. A. D. Fallows, Asst. Cmd. Adj., Hq., ADC, to Cmdr., AFSWC, 15 Mar. 1957; ltr., RAdm. E. Hall Hanlon, Cmdr., JTF-7, to Cmdr., AFSWC, 14 Mar. 1957, subj.: Positioning of Aircraft

Supporting Nuclear Tests; ltr., K. F. Hertford, Mgr., ALOO, to Brig. Gen. Canterbury, 19 Mar. 1957, subj.: Positioning of Aircraft Supporting Nuclear Tests; ltr., G. W. Johnson, Test Dir., USAEC Nevada Test., Org., to Hq., AFSWC, Attn.: Brig. Gen. Canterbury, 11 Mar. 1957, subj.: Memo. dated 25 January 1957 - (U) Positioning of Aircraft Supporting Nuclear Tests, see App.

26. Ltr., J. W. Klopp, Ch., BUAER, to Cmdr., AFSWC, 26 Feb. 1957, subj.: Positioning of Aircraft Supporting Nuclear Tests, see App.

CHAPTER VIII

OPERATION PLUMBBOB, A NEW ORGANIZATION

With the establishment of the 4950th Test Group (Nuclear) at the Air Force Special Weapons Center on 1 September 1956, the 4926th Test Squadron (Sampling) became a part of that group. The squadron's mission had not changed but rather dovetailed into its organization and functions. This fact was born out during Operation PLUMBBOB.

Mission of the 4950th Test Group (Nuclear)

The primary mission of the 4950th Test Group (Nuclear) during Operation PLUMBBOB was ". . . to provide limited support and control the aircraft necessary to collect and record data required by the participating services, commands, and the Atomic Energy Commission." The test group was also responsible for:[1]

(1) Performance as the air support group for the Atomic Energy Commission test manager.

(2) Assumption of operational control over all aircraft participating in test, support, and practice sorties over and in the vicinity of the Nevada Test Site during the operational phase of the test series.

(3) Provision and operation of an AN/USQ-12 IFF facility in the Air Operations Center, together with its allied radio equipment, to control test and support aircraft and exercise supervisory and coordinative control of devices used for precise aircraft positioning.

(4) Planning, organization, publication, and dissemination of integrated flight plans and patterns for all participating aircraft.

(5) Provision of an air sampling capability to collect particulate and gaseous matter from nuclear detonations.

(6) Conducting of radiation safety operations at Indian Springs Air Force Base and Kirtland Air Force Base.

(7) Arrangement for airlift and air support as required by the test manager and the deputy for the Department of Defense participants.

(8) Arrangements for provision of disaster teams as required.

(9) Assumption of Air Force Special Weapons Center responsibility for the safe positioning of all participating aircraft.

(10) Conducting of crew briefings and provision of operational instructions for aircrews staging from Kirtland Air Force Base.

(11) Conducting of positioning conferences.

(12) Arrangement with other Special Weapons Center elements for messing, housing, office and laboratory space, and administrative and housekeeping support for test participants based at, or staging through Kirtland Air Force Base.

Manning the 4950th Test Group (Nuclear)

When the 4950th Test Group (Nuclear) was established, on 1 September 1956, a new manning concept was inaugurated to augment the Air Force Special Weapons Center during nuclear testing. Under this new concept, personnel were assigned to the 4952nd Support Squadron (a 4950th subordinate unit) at Kirtland Air Force Base and were sent to augment the 4935th Air Base Squadron at Indian Springs Air Force Base on temporary duty. These personnel had "staggered" reporting dates at Indian Springs to conform with the previously established build-up schedule. The Unit Manning Document authorizations for the 4952nd Support Squadron during test periods, therefore, were over and above interim requirements. Inasmuch as these augmentation personnel were on temporary duty with the 4935th Air Base Squadron, their station of assignment was Kirtland, rather than Indian Springs.

In September 1956, personnel to man the 4952nd Support Squadron were requisitioned upon the assumption that Operation PLUMBBOB would start about 1 February 1957. Following organization of the 4950th Test Group (Nuclear), however, definitive PLUMBBOB information began to appear. The 4950th, therefore, requested that the Center readjust by 30 days all reporting dates of personnel for the 4952nd Support Squadron. These dates were changed, and all Air Force units levied upon were advised of the change.

When starting date for Operation PLUMBBOB was again delayed, a second attempt was made to delay personnel reporting dates. This attempt, however, was not successful, and personnel began to arrive at Kirtland Air Force Base in December 1956. These men could not be used effectively within the 4950th or the 4952nd Support Squadron during the months before the beginning of PLUMBBOB, therefore, they were loaned to various units at Kirtland until needed in the test program.

Peak personnel strength in the 4950th during PLUMBBOB was as follows:

	Officers	Airmen
Headquarters, 4950th Test Gp. (N)	23	50
4935th Air Base Squadron	13	237
4952nd Support Squadron	4	185
	40	472

When the operational phase of Operation PLUMBBOB began, the following officers occupied the indicated key positions in the 4950th Test Group

(Nuclear):

Commander	Colonel Paul R. Wignall
Deputy Commander	Colonel Alden G. Thompson
Director of Operations	Lt. Colonel Richard J. Hynes
Operations Staff Officer	Lt. Colonel Walter B. Walker, Jr.
Aircraft Controller Staff Officer	Major Alan W. Ericson
Communications-Electronics Officer	Lt. Colonel Warren B. Fackenthall
Adjutant	Major Max B. Canyard
Director of Materiel	Lt. Colonel Carl W. Robbins, Jr.

Operational Planning

The major planning conference for Operation PLUMBBOB was conducted by the 4950th Test Group (Nuclear) at Kirtland Air Force Base on 6 and 7 February 1957. The purpose of this conference was (1) to coordinate all planned air activities, (2) to ascertain that all scientific programs and projects were being satisfied insofar as positioning and control of aircraft were concerned, and (3) to coordinate logistics requirements of the participating organizations.

At the conference, Colonel Carl A. Ousley, then group deputy commander and commander of the Test Aircraft Unit, defined the concept of operation and the organization of the Test Aircraft Unit, which included the 4926th sampling squadron, the Wright Air Development element, the Navy element, the Tactical Air Command element (helicopters), and the [redacted] delivery element. Colonel Ousley would command approximately 37 aircraft. The Test Aircraft Unit was to have operational control over all units and agencies involved in technical air operations at Indian Springs Air Force Base, and would coordinate logistics as necessary to allow participating

Colonel Carl A. Ousley, commander of the Test Aircraft Unit, check sampling mission with Major Malcolm S. Bounds (left), commander of the 4926th Test Squadron (Sampling), and Dr. Harold F. Plank (right), scientific director of the cloud sampling program, Operation PLUMBBOB elements to accomplish their missions. This would include scheduling of aircraft and readjustments of housing requirements or work space in case of conflict. Test Aircraft Unit would control aircraft until they became airborne, Colonel Ousley explained, and upon re-entry to the Indian Springs traffic pattern prior to landing. Control of aircraft in the Nevada Test Site Control Area would be the responsibility of the Air Operations Center, located at the Atomic Energy Commission's Control Point.

General subjects discussed at the conference included security, funding, facilities and services available at Indian Springs Air Force Base, communications, Air Operations Center activities, general flying operations, training and operation projects, documentary photography, and support. The 4900th Air Base Group at Kirtland would coordinate and control certain aircraft engaged in support. These aircraft, furnished by major Air Force commands, would perform such functions as passenger and cargo shuttle flights between Kirtland and Indian Springs, courier flights, low-level cloud tracking, terrain survey, and special mission flights.

A particularly important portion of the conference was concerned with determining aircraft positioning for each of the planned PLUMBBOB shots. Twenty-one positioning diagrams were drawn up, along with brief descriptions of programs and project activities in the shots. These diagrams were published on 20 February 1957.[2]

Operation Plan

Planning Directive 3-56 was the primary planning guide for Operation PLUMBBOB activities until 1 April 1957, when the 4950th Test Group (Nuclear) published Operation Plan 1-57. This plan described the Air Support Group--the 4950th's forward echelon at Indian Springs--as having an operational headquarters and two major operational units. The two operational units were the Test Aircraft Unit and the 4935th Air Base Squadron, which operated Indian Springs Air Force Base. A third operational unit was provided by the 4900th Air Base Group at Kirtland. This latter unit provided courier and shuttle service between Kirtland and Indian Springs.

The Planning Directive gave the Test Aircraft Unit responsibility for test operational flying activities, particularly (1) test crew briefing, (2) control of sampler and cloud tracker aircraft, (3) radiological and weather reconnaissance flights, (4) providing some maintenance facilities at Indian Springs, and (5) coordinating takeoff and landing schedules.

The 4935th Air Base Squadron, commanded by Major Harry E. Elmendorf, was responsible for (1) housing, messing, and some administrative and logistic support for aircraft and crews staging from Indian Springs Air Force Base, (2) security and controls and identification procedures for Indian Springs, (3) operation of a dispatching office, refueling facilities, and crash fire fighting in the Nevada Test Site area, and (5) operating an airlift between Indian Springs and the Yucca Lake airstrip. Operation Plan also outlined Operation PLUMBBOB procedures and policies for personnel and administration functions, operations (including aircraft participation, flying safety, and support aircraft procedures), air control, communications, radiological safety, logistics, security and intelligence, information services and funding.[3] With very minor changes, the Operation Plan became the Operation Order 1-57 on 1 May 1957.[4]

Aircraft Requirements

The Operations Directorate, 4950th Test Group (Nuclear), on 18 February 1957, drew up a list of aircraft for Operation PLUMBBOB. They included 29 test aircraft, 34 support aircraft, and an unspecified number of some 14 different types of aircraft for operations and training. The test aircraft number, types, and missions, all to operate from Indian Springs Air Force Base, were listed as follows:

TYPE	NUMBER	MISSION
F-84G	11	Sampling
B-57	6	Sampling
F-89	2	MB-1 delivery
F-89	2	Effects studies
FJ4	2	Effects studies
A4D	2	Effects studies
Helicopters	2	Effects studies
Blimps	2	Effects studies

The number of aircraft for support activities, their types, and missions were as follows:

TYPE	NUMBER	MISSION
B-29/B-50	2	Cloud tracking
B-25	2	Cloud tracking
T-33 (Air National Guard)	4	Sampling
C-47	1	Photography
C-47	1	Radio relay
C-47	4	Courier flights
C-119	4	Airlift
B-25	2	Courier flights
C-45	5	Security sweeps
L-20	3	Security sweeps
H-21	6	Radiological surveys Sample recovery Damage surveys

The exact number of aircraft for operations and training was unknown. In fact, these aircraft came from several military agencies, their numbers remained fluid even after Operation PLUMBBOB got under way. Three B-47 aircraft from the Strategic Air Command were scheduled for indirect bomb damage assessment, but only the types of the remaining operations and training aircraft were specified.[5] Many of these aircraft staged from such scattered places as Kirtland, March, George, Edwards, and Nellis Air Force Bases.

The PLUMBBOB Operation Plan, published on 1 April 1957, listed the following types and number of aircraft for the indicated test support missions:

TYPE	NUMBER	MISSION
B-57B	6	Sampling
F-84G	11	Sampling
T-33	4	Sampling
F-89J	2	[redacted] delivery
HSS1	2	Effects studies
ZSG (blimps)	2	Effects studies
FJ4	2	Effects studies
A4D	2	Effects studies
F-89D	2	Effects studies
B-50	1	Cloud tracking
B-25	2	Cloud tracking
B-29	1	Cloud tracking
H-21	6	Radiological surveys Taxi service
B-25	2	Sample return and courier
C-47	4	Sample return and courier
C-47	1	Photography
C-119	4	Airlift
L-20	3	Security sweeps and CRT
C-45	3	Security sweeps and CRT
C-47	1	Terrain survey
L-21	3	Terrain survey

The above differed only slightly from the list issued on 18 February 1957.[6]

Sampling Plans

The tentative plans called for eleven F-84G and six B-57 samplers, including four T-33 aircraft from the Air National Guard. This list remained firm throughout planning period and appeared in the above. The Operation Plan stated, ". . . gaseous and particulate samples of PLUMBBOB events will be collected by aircraft and aircrews provided by the 4926th Test Squadron (Sampling)." Major Richard S. Bounds, the commander, was responsible for the sampling mission. His specific responsibilities included (1) briefing aircrews, mission execution, and all airborne sampler activity and control, and (2) handling of all samples, decontamination, and adherence to safety procedures.

As usual, the sampler pilots, immediately after takeoff from Indian Springs, came under the control of the air operations at the Nevada Test Site control point. They were directed to the B-57B sampler control aircraft. When visual contact was made with the control B-57, the sampler pilot received instructions from the scientific advisor aboard, following directions on cloud penetrations. When the mission was completed, the sampler pilot received vectoring back to Indian Springs, where he landed. By now, this method of operation had become standard and routine for the 4926th.

Sampling missions flown by the Air National Guard were unique, however. On 29 November 1956, Captain Joseph Price, from AFOAT-1 (Office of the Assistant for Atomic Energy), visited the Air Force Special Weapons Center to discuss sampler training for Air National Guard pilots. The proposed program would train Air National Guard personnel for duties they

Airman Buford Jackson Plots Position of F-84G Sampling Aircraft, Operation PLUMBBOB

would perform in case of a national emergency. Therefore, AFOAT-1 planned a sampling requirement apart from those of the Los Alamos Scientific Laboratory and the University of California Radiation Laboratory.[7] Colonel Wignall, 4950th commander, approved the Air National Guard sampler training on 1 December 1956, and included them in the early planning for Operation PLUMBBOB.

Shots and Aircraft Participation

A total of 875 different sorties were planned for Operation PLUMBBOB, and 786 of these missions were completed. There were 17 air aborts, while

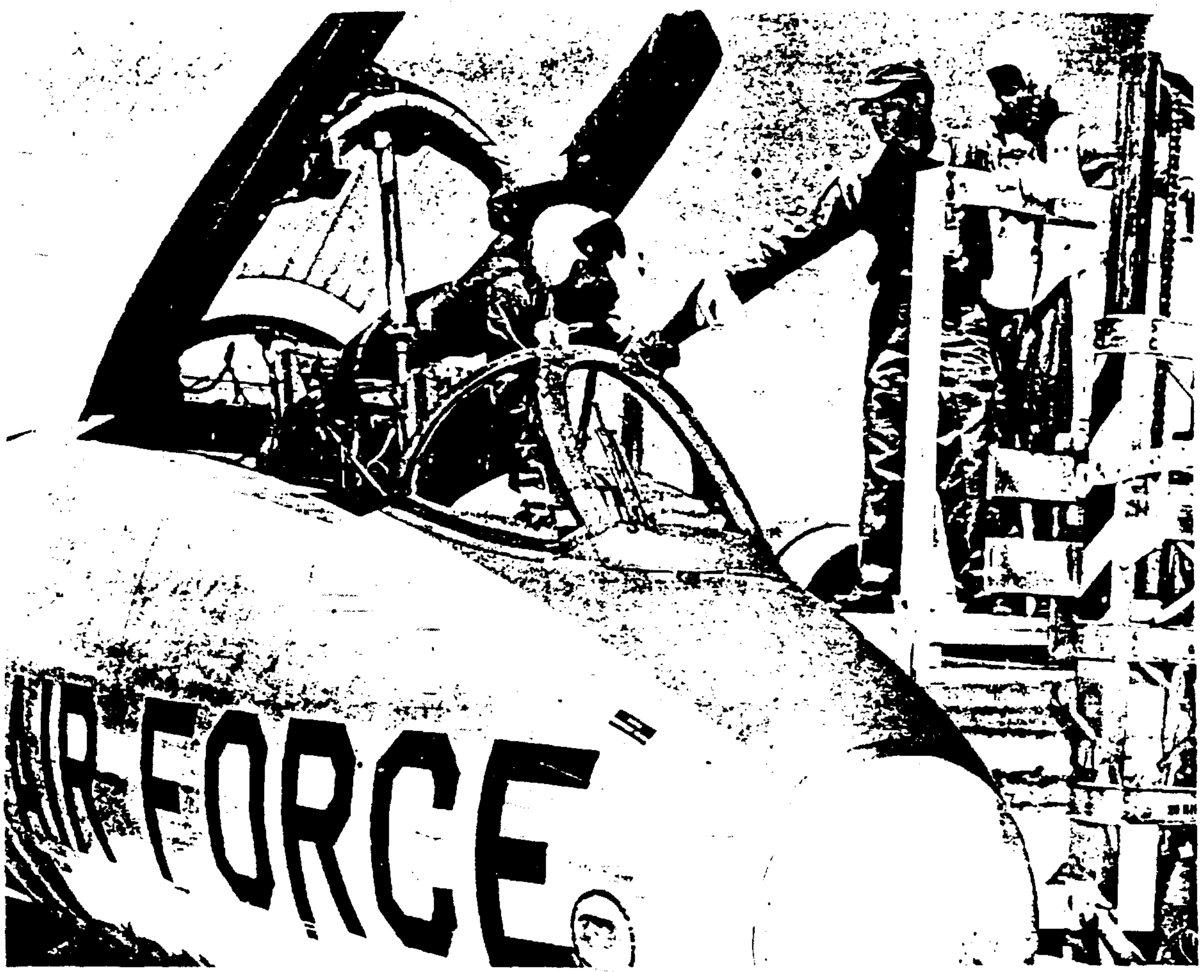
70 aircraft missions were cancelled, many of them because of requirements. This happened frequently during the later weeks of the test series.[8]

Chart: Schedule for Operation PLUMBBOB *

Shot	Date	Type	Remarks
BOLTZMAN	28 May 1957	500-foot tower	
FRANKLIN	2 June 1957	300-foot tower	
LASSEN	5 June 1957	500 feet balloon	
WILSON	18 June 1957	1,700 feet balloon	
PRISCILLA	24 June 1957	700 feet balloon	
COULOMB A	1 July 1957	Surface	Not sampled
HOOD	5 July 1957	1,000 feet balloon	
DIABLO	15 July 1957	500-foot tower	
JOHN	19 July 1957	18,000 feet altitude	[redacted] launched from F-89J
KEPLER	24 July 1957	500-foot tower	
OWENS	25 July 1957	500 feet balloon	
PASCAL A	26 July 1957	Well	Not sampled
STOKES	7 August 1957	1,000 feet balloon	

*See Appendix II for number of samples taken on each shot.

Shot	Date	Type	Remarks
SATURN	9 August 1957	Tunnel	Not sampled
SHASTA	18 August 1957	500-foot tower	
DOPPLER	23 August 1957	1,000 feet balloon	
PASCAL B	27 August 1957	Well	Not sampled
FRANKLIN	30 August 1957	750 feet balloon	An F-84 sampler aborted because of communication problems
SMOKEY	31 August 1957	700-foot tower	
GALILEO	2 September 1957	500-foot tower	
WHEELER	6 September 1957	500 feet balloon	
COULOMB B	6 September 1957	Surface	No sampling
LAPLACE	8 September 1957	750 feet balloon	
FIZEAU	14 September 1957	500-foot tower	
NEWTON	16 September 1957	1,500 feet balloon	
RAINIER	19 September 1957	800 feet underground	
WHITNEY	23 September 1957	500-foot tower	
CHARLESTON	28 September 1957	1,500 feet balloon	
MORGAN	7 October 1957	500 feet balloon	



Some difficulty developed because air participants often operated from widely dispersed air bases and getting shot information to them was difficult, if not impossible. A good example of this was the rescheduling of SHASTA Shot after it had been postponed. Not only was it difficult to reassemble aircrews but safety flight was compromised because of hasty mission preparations and the lack of crew rest.

VIII

During Operation PLUMBBOB, the 4926th Test Squadron (Sampling) operated on a dual base concept due to the lack of adequate maintenance space at Indian Springs. All periodic inspections and controlled major maintenance of F-84G and B-57B aircraft were performed at Kirtland. Unscheduled major maintenance at Indian Springs was held to a minimum through aggressive daily and preventive maintenance and sound programing of aircraft utilization. The average strength at the Kirtland detachment was 1 officer and 40 airmen. The strength of the forward element at Indian Springs Air Force Base averaged 26 officers and 130 airmen.

During the operation, the flying time for B-57B aircraft was 796:45 hours; for F-84G aircraft 1,331:55 hours; and for T-33A aircraft 541:45 hours. Total flying time was 2,669:45 hours of which 175:45 hours were logged during test mission sorties. Total number of sorties flown was 1,821 which included 161 test mission sorties. A total of 1,932 takeoffs and landings were recorded. There were seven aborts due to reasons other than shot cancellations. An in-commission rate of 88 per cent was sustained while the aircraft-out-of-commission-for-parts rate was held to less than one per cent. In preparing for and successfully completing Operation PLUMBBOB, the 4926th Test Squadron established an enviable flying safety record, winning the Air Force Special Weapons Center first quarterly flying safety award.

SWEH-2-0034

191

AFWL/HO

CHAPTER VIII

NOTES

1. Planning Directive 3-56.

2. Ltr., Col. P. R. Wignall, Cmdr., 4950th TG (N), USAF, et al., 20 Feb. 1957, subj.: Resume of Planning Conference 6 and 7 Feb. 1957, in Hist. Div. files, Operation PLUMBBOB.

3. Operational Plan 1-57, 4950th TG (N), 1 Apr. 1957, in Hist. Div. files, Operation PLUMBBOB.

4. Ibid., Amend. No. 1, 24 Apr. 1957.

5. Black Book, "List of Aircraft to Participate in PLUMBBOB," Dir. of Ops., 4950th TG (N), in Hist. Div. files, Operation PLUMBBOB.

6. Operation Plan 1-57, 1 Apr. 1957.

7. Memo., Ch. Ops. Sec., 4950th TG (N), to Cmdr., 4950th TG (N), 30 Nov. 1956, subj.: Visitation of AFOAT-1 Representatives, in Hist. Div. files, Operation PLUMBBOB.

8. Mission Summary Reports for Operation PLUMBBOB, BOLTZMAN 28 May 1957, FRANKLIN 2 June 1957, LASSEN 5 June 1957, WILSON 18 June 1957, PRISCILLA 24 June 1957, HOOD 5 July 1957, DIABLO 15 July 1957, JOHN 19 July 1957, KEPLER 24 July 1957, OWENS 25 July 1957, STOKES 7 Aug. 1957, SHASTA 18 Aug. 1957, DOPPLER 23 Aug. 1957, FRANKLIN PRIME 30 Aug. 1957, SMOKEY 31 Aug. 1957, GALILEO 2 Sep. 1957, WHEELER 6 Sep. 1957, LAPLACE 8 Sep. 1957, FIZEAU 14 Sep. 1957, NEWTON 16 Sep. 1957, RAINER 19 Sep. 1957, WHITNEY 23 Sep. 1957, CHARLESTON 28 Sep. 1957, and MORGAN 7 Oct. 1957.

This chapter is largely a resume of the pertinent sections as found in special study Operation PLUMBBOB, in Hist. of AFSWC, 1 July - 31 December 1957, Vol. I, pp. 132-188.

CHAPTER IX

OPERATION HARDTACK AND DUAL SHOTS

Like previous operations, planning for HARDTACK began ~~several years~~ in advance of the operation. It was marked by the many and monumental last-minute changes and the test series was notable for deficiencies in both sampling pilots and aircraft. Officials also faced the problem of obtaining a sufficient number of commissioned observers.[1]

As early as June 1955, Headquarters, Air Force Special Weapons Center, received notification of HARDTACK, the location was undetermined, and the probable number of detonations would be 10.[2] Field Command, Armed Forces Special Weapons Project, warned that the information was "very preliminary and will probably change considerably before final program is established."[3]

As early as 3 December 1956, actions forecasting sampling difficulties were taken when General Perry B. Griffith, Joint Task Force SEVEN, wrote:

> The current concept being envisaged for Operation HARDTACK contemplates the probable firing of two shots on the same day on some occasions, and perhaps in a few instances, at the same time. However, while some additional aircraft will be required, it is realized that a complete dual sampling capability probably cannot be supported, nor is it justified. Therefore, in order to have an adequate number of sampling aircraft available on dual shot day, attempts will be made to have one of the scheduled shots a low yield detonation requiring relatively limited participation so far as sampling aircraft is concerned.[4]

Later in the month, Gaelen L. Felt, Commander, Task Group 7.1, advised Rear Admiral B. Hall Hanlon, Commander, Joint Task Force SEVEN, of the sampling requirements. "A significant assumption made by both laboratories is that there will be a general indorsement of the indicated extension of the dual capability concept. A dual capability which considers the firing of two large shots, instead of the REDWING capability of one large and one small, is an important corollary to any plan we may develop to make effective use of the Eniwetok site." Thus, the argument effectively altered the "big-shot-small-shot" plan suggested by General Griffith.[5]

On 27 April 1957, the Chief of Staff, United States Air Force, registered official "go-ahead" for HARDTACK:

> The Atomic Energy Commission and the Department of Defense are planning for Operation HARDTACK, 1958 overseas weapon test, scheduled for Eniwetok Proving Ground. The tentative starting date is 1 May 1958. Approximately 30 devices will be tested during Operation HARDTACK. The United States Air Force will be the executive agent for the test series and Air Force participation will follow the general pattern established during previous overseas nuclear tests. ARDC (Air Research and Development Command) will man, train, and organize Air Task Group 7.4. The Air Task Group will consist of three units, (1) a Test Base Unit provided by ARDC, (2) a Test Aircraft Unit organized by ARDC but composed of elements provided by major USAF commands and Department of Defense agencies operating aircraft, and (3) a Test Support Unit provided by MATS (Military Air Transport Service). The mission and function of Task Group 7.4 and subordinate units will parallel those assigned for Operation REDWING. Reference should be made to Task Group 7.4 REDWING planning directive, Task Group 7.4 Operations order 1-56, and the Final Report of the Commander, Task Group 7.4 for Operation REDWING. This message constitutes authority for initial planning for Operation HARDTACK by concerned USAF commands and units. Detailed instructions covering this operation will be furnished on or about 1 July 1957.[6]

Then on 11 October 1957, the Chief of Staff, notified Task Group 7.4, and the Air Force Special Weapons Center that, "The Chief of Staff, as Executive Agency has issued the necessary directive to Commander, Joint Task Force SEVEN for conducting the operation (HARDTACK). To support this operation, Headquarters USAF hereby directs organization of Task Group 7.4, at earliest practicable date. . . The Commander, Task Group 7.4 is authorized to organize these units and elements as may be required by operational necessity."

In the implementing instructions was the following list of units and elements including provisions for sampling:

(a) Headquarters Task Group 7.4 (Provisional).

(b) Test Base Unit with the following elements:

Support squadron
Helicopter element

(c) Test Aircraft Unit with the following elements:

Cloud sampling element (augumented by 6 SAC B-57D aircraft).
Air Force effects elements (includes IBDA, VHA/UHA, ionosphere elements).
Navy effects element (to be provided by NASWF, Kirtland AFB, New Mexico, and attached to the Test Aircraft Unit for operational control).

(d) Test Service Unit with the following elements:

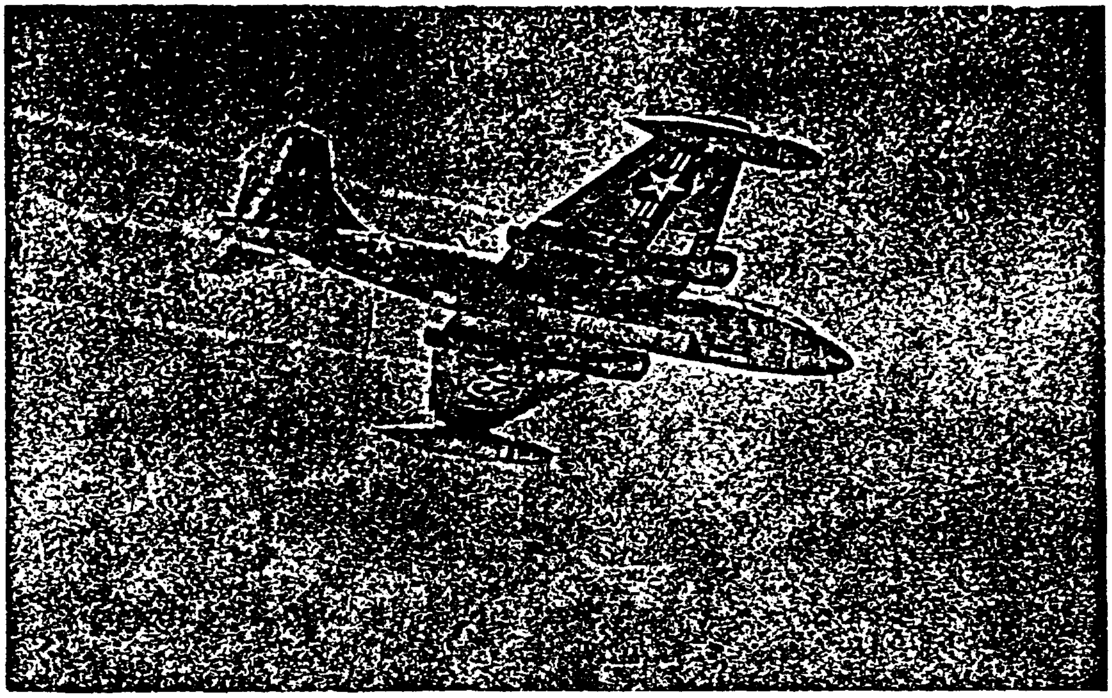
Search and rescue element (to include weather island re-supply).
Weather reporting and forecasting element.
Weather reconnaissance element.
Communications element (AACS).
Weather central element.
MATS terminal element.
Aerial photo element. 7

Foreseeing the difficulties from non-Air Force organizations as in earlier tests, Special Weapons Center officials took early action to insure positive orders were issued to all supporting commands by Air Force headquarters. "Book Message" became the byword, and several drafts of the proposed Air Force message were prepared and coordinated in the hopes of evolving a directive which would effect the required actions by Air

Force commands other than Air Research and Development Command.[8] Tentatively, the starting date for HARDTACK was 1 May 1958,[9] then moved up to 15 April. The first test of a "laboratory device" was set for 1 May, TEAK was to be executed as early as readiness would permit, but no later than 23 April with YUCCA and ORANGE following as closely as possible.[10]

On January 6, 1958, Headquarters, Task Group 7.4, Provisional, issued Operation Plan 1-58, "Operation HARDTACK," and its size and thoroughness reflected the vast amount of experience accumulated during earlier tests. The Planning Directive 5-57 had been published, and stated planning requirements for each of the sections while other organizations eventually followed with detailed planning. Although no B-57D aircraft were available to the 4926th Test Squadron (Sampling), the Strategic Air Command had been directed to furnish six B-57D aircraft with crews and maintenance personnel. The Strategic Reconnaissance Wing (Light) received its sampling responsibilities sufficiently early so that its Operations Order 14-58 joined the libraries amassed by the other sections assigned to HARDTACK. Certainly, judging from the attractive, thoroughly prepared, published plans, HARDTACK promised to be a military operation which enjoyed unprecedented smoothness.

Organized on 1 October 1957, simultaneously with other elements, was the Cloud Sampling Unit, Provisional, at Kirtland; the Ultra High Altitude-Very High Altitude Aircraft Element, Provisional; the Air Force Effects Element, Provisional, at Wright-Patterson Air Force Base, Ohio; and the Ionosphere Element, Provisional, at Laurence G. Hanscom Field, Bedford, Massachusetts. All were organized as segments of the Test



B-57 Sampler, Operation HARDTACK, Note Wing-tip Filter System

Aircraft Unit and Task Group 7.4, Provisional. The mission of the Test Aircraft Unit was defined thusly: to provide, maintain, and operate aircraft for the task group. It consisted of the Cloud Sampling Element augmented by six B-57D aircraft of the 4080th Strategic Reconnaissance Wing (Light), the Indirect Bomb Damage Assessment Element, the Very High Altitude-Ultra High Altitude Aircraft Element, the Ionosphere Element, the Air Force Effects Element, and the Navy Effects Element provided by Naval Air Special Weapons Facility, Kirtland Air Force Base.[11] As of the 17th of October 1957, tentative plans called for having the Cloud Sampling Element in place at Eniwetok by 15 March 1958. The other elements of the Test Aircraft Unit also received readiness dates.

Aircraft designated as available for the operation were sixteen B-57 (ten B-57B of the 4926th Test Squadron (Sampling) and six B-57D from the Strategic Air Command); one B-52 from Wright Air Development Center, for effects projects; two B-36 from the Special Weapons Center, for the very high altitude-ultra high altitude projects; one C-97 from Cambridge Research Center, for ionospheric studies; two A4D, two FJ4 and one P2V from Naval Air Special Weapons Facility at Kirtland Air Force Base, for effects and study projects and three B-47 from Strategic Air Command, for indirect bomb damage assessment, operating out of Guam.[12]

Although plans called for having the six B-57D aircraft on hand for cloud sampling, project officials encountered difficulties in obtaining modifications and sampling tanks. As a result, six of the eleven F-84 aircraft scheduled for destruction were being held intact should the B-57D aircraft not be completed in time.[13] The scientist, Philip R.. Moore, J-11, Los Alamos, described these difficulties even after approval for the planes had been secured:* [14]

> At a big conference at the Martin plant in Baltimore, we learned that Martin simply wasn't going to meet the deadline on either the modifications or the sampling tanks, the contracts for which they had accepted. Immediately we determined the true situation with Martin, we searched other sources for modification and production. Although Warner-Robins Air Materiel Command was already modifying four B-57B aircraft for the sampling operation, they agreed to take over the modifications of the B-57D aircraft as well, promising deadline delivery.
>
> As LASL had designed the sampling tanks, and they

---

*See Suitable Sampling Aircraft Chapter, <u>infra</u>.

were LASL's responsibility, we immediately sought a contractor who could produce them. Having previous experience with Fletcher Aircraft of Rosemont, California, we sought their aid and they accepted the contract. Shortly, we realized that they had not assigned a single engineer to the project, so we cancelled the contract and split the tank procurement into two separate contracts. Producing the section in front of the filter paper was given to specialists in working with stainless steel--Solar Aircraft of San Diego. The portion in the rear of the filter paper was accepted by Century Engineers in Burbank.

Both outfits came through by assigning crews for round-the-clock-work and the first pair of tanks for operational testing arrived at Kirtland one week before the 4926th was scheduled to depart for the proving ground.

Immediately the pilots started testing operations and vibration tests were performed by the 4950th Test Group (Nuclear).

Despite the terrific work load already on the 4926th because of packing requirements for the test, they took on the additional testing missions, worked day and night through that entire week, and detected aerodynamic trouble in the tanks. A vortex effect developed behind the pylon housing; this hammered at the tank tail section so that it cracked. An on-the-spot modification was made, the tanks retested and the modification proved successful. Orders were sent to Century Engineers to similarly modify all tanks under production or already produced and the tanks gave their anticipated service life throughout subsequent tests.

Meantime at Warner-Robins, modifications crews were also working day and night and they too succeeded in meeting the deadline. Both accomplishments were excellent and far above the level of production ordinarily achieved.

Although not associated with manned aircraft sampling of nuclear clouds, an attempt to sample by use of rockets was made during GREENHOUSE. The five-inch rockets were fired from one island, were supposed to pierce the nuclear cloud and land on a third island. Preliminary tests showed excellent promise. But when the actual detonation occurred, the shock wave deflected the rockets and most of them landed in the ocean. We recovered some nose cones, but generally so much time was lost in locating them and in digging for

> them that their samples were of little value. You see, a radio-chemist is continuously fighting to gain time--fighting the half-life of radioactive particles. Unless we can analyze a sample promptly, we cannot determine the many things we must know.
>
> In nuclear testing, unlike testing of other devices, we must determine the maximum from each test in order to avoid atmospheric and aircrew contamination as much as possible. In testing other devices, there is no contamination, only financial cost to consider. Therefore, radiochemists must obtain samples which will allow us to recreate the chain of events which took place in a few milliseconds. Obtaining these samples through use of manned sampling aircraft has been by far the best controlled and reliable method.

Virtually all members of the 4926th Test Squadron had experience in sampling procedures, fortunately, or had received preliminary training by April 1958. The B-57B transition training program suffered some early delays while aircraft underwent modifications; however, by February 1958, the program had intensified to such a degree that crew members acquired sufficient training in long-range navigation and link trainer flights, the latter simulating all instrument approaches likely to be encountered during the operations. The program also included shakedown flights on each aircraft to determine exact fuel consumption rates.[15]

Crew members of the 4926th also received radiological safety courses. Because of the lack of qualified aircrew observers, other qualified personnel of Task Group 7.4 underwent this radiological safety training to provide adequate supply of trainer observers and to allow an equable radiation exposure among the several observers. The 4926th supervised a similar over-all training program at Laughlin Air Force Base during February 1958 for the Strategic Air Command crews. Both the B-57B and the B-57D training programs were completed by the end of March 1958.

On 1 April 1958, the ten B-57B aircraft departed from Kirtland Air Force Base on the first leg of the trip to Eniwetok Proving Ground. At McClellan Air Force Base, the first stop enroute, the aircraft encountered a delay of some 12 days caused by adverse winds over the Pacific, but finally arrived at Eniwetok on 18 April 1958. The three remaining B-57B aircraft arrived on 21 April 1958. They were readied immediately for sampling missions.[16] The B-57D aircraft left Laughlin Air Force Base, accompanied by two C-124 support aircraft carrying maintenance personnel and equipment, on 6 April 1958. They also encountered adverse winds and arrived at Eniwetok on 14 April 1958. With few exceptions, the personnel and equipment for sampling were in place for operations by mid-April.

As specified by Air Force, the Los Alamos Scientific Laboratory, and the University of California Radiation Laboratory, the number of samples ranged from one to ten, collected at various altitudes and depending upon the nature of the shot.[17]

Shot and Aircraft Participation: Phase I

Despite a proposed advancement of the starting date for HARDTACK, Phase I, the first shot, YUCCA, did not occur until 28 April. During Phase I, which eventually included a total of 33 individual shots, sampling aircraft flew 240 missions and logged 1,635 flying hours.

Chart: Sampling HARDTACK, Phase I*

Shot	Date	Type	Remarks
YUCCA	1440 28 April 1958	Balloon	Drifted to 60 miles NE of Eniwetok

*See Appendix II for number of samples taken on each shot.

Shot	Date	Type	Remarks
CACTUS	0615 6 May 1958	Surface	Eniwetok; light sampling
FIR	0550 12 May 1958	Barge	Bikini; seven samplers engaged
BUTTERNUT	12 May 1958	Surface	Bikini; five samplers engaged
KOA	0630 13 May 1958	Surface	Eniwetok; ten samplers participated
WAHOO	1300 16 May 1958	500 feet Underwater	Eniwetok; three sampling aircraft
HOLLY	0630 21 May 1958	Barge	Eniwetok; five samplers participated
NUTMEG	0920 22 May 1958	Barge	Bikini; seven samplers
YELLOWWOOD	1400 26 May 1958	Barge	Eniwetok; six samplers performed
MAGNOLIA	0600 27 May 1958	Barge	Eniwetok; five samplers
TOBACCO	1415 30 May 1958	Barge	Eniwetok; five samplers
SYCAMORE	1500 31 May 1958	Barge	Bikini; eight samplers in all, three B-57B substituted for B-57D aircraft because of unexpected low cloud ceiling

Shot	Date	Type	Remarks
ROSE	0645 3 June 1958	Barge	Eniwetok; five sampler aircraft participated
UMBRELLA	1115 9 June 1958	150 feet Underwater	Eniwetok; four samplers
MAPLE	0530 11 June 1958	Barge	Bikini; one B-57 aborted with flame-out, eight samplers took part
ASPEN	0520 15 June 1958	Barge	Bikini; six sampler aircraft
WALNUT	0630 15 June 1958	Barge	Eniwetok; ten samplers
LINDEN	1500 18 June 1958	Barge	Eniwetok; five samplers used
REDWOOD	0530 28 June 1958	Barge	Bikini; six samplers participated
ELDER	0630 28 June 1958	Barge	Eniwetok; five samplers
OAK	0730 29 June 1958	LCU hull	Eniwetok; eleven samplers
HICKORY	1200 29 June 1958	Barge	Bikini; six samplers participated
SEQUOIA	0630 2 July 1958	Surface	Eniwetok; five samplers
CEDAR	0530 3 July 1958	Barge	Bikini; seven samplers, a B-57D suffered a dual flame-out at 50,000 feet altitude. One engine recovered and the aircraft was escorted to FRED

Shot	Date	Type	Remarks
DOGWOOD	0630 6 July 1958	LCU hull	Eniwetok; eight samplers took part
POPLAR	1530 12 July 1958	Barge	Bikini; six samplers
SCAEVOLA	1600 14 July 1958	Surface	Eniwetok; no sampling
PISONIA	1100 18 July 1958	LCU hull	Eniwetok; five samplers participated. A B-57B (HOTSHOT II) aborted and the B-57B (HOTSHOT PHOTO) had in-operative IFF equipment.
JUNIPER	1620 22 July 1958	Barge	Bikini; four samplers. A B-57D(HARDTIMES II) blew tires on landing.
OLIVE	0830 23 July 1958	LCU hull	Eniwetok; five samplers involved
PINE	0830 27 July 1958	LCU hull	Eniwetok; seven samplers took part with no incident
TEAK	2350 31 July 1958	Missile shot above Johnston Island	No samplers
QUINCE	1415 6 August 1958	Surface	Eniwetok; three samplers
ORANGE	2330 11 August 1958	Missile shot above Johnston Island	No samplers
FIG	1600 18 August 1958	Surface	Eniwetok; four samplers

Two shots, TEAK and ORANGE were rightfully a part of HARDTACK Phase I but were relocated to Johnston Island and became Operation NEWSREEL.[18] With FIG Shot, Phase I came to an end and Operation HARDTACK moved into Phase II at the Nevada Test Site. Through Phase I, the sampler squadron suffered no accidents and carried out missions as planned.

Shots and Aircraft Participation: Phase II

The cloud sampling mission presented problems for Phase II. Most of the airplanes, equipment, supplies, and radiation instrumentation were enroute from Eniwetok and not expected to arrive until 25 September 1958. Some equipment, however, had been returned to Kirtland earlier for a special project and proved adequate for the Nevada tests. The famous sampling squadron performed all requirements successfully during Phase II.

Aircraft staged from Indian Springs Air Force Base, with a forward area detachment to fly the sampling missions and associated activities. Meanwhile, the squadron headquarters remained at Kirtland and all major maintenance took place at the latter base.[19]

Chart: Sampling HARDTACK, Phase II*

Shot	Date	Type	Remarks
OTERO	12 September 1958	500-foot well	Two B-57 samplers on hand
BERNALILLO	17 September 1958	Well	Aircraft stood by
EDDY	19 September 1958	500 feet balloon	One B-57 controller and four B-57 samplers took part.

*See Appendix II for number of samples taken on each shot.

Shot	Date	Type	Remarks
LUNA	21 September 1958	500-foot well	One sampler controller and one sampler participated
MERCURY	23 September 1958	Tunnel	No aircraft
VALENCIA	26 September 1958	300-foot well	One sampler controller and one sampler participated
MARS	27 September 1958	Tunnel	No aircraft
MORA	29 September 1958	1,500 feet balloon	One B-57 sampler controller and four B-57 samplers
HIDALGO	5 October 1958	400 feet balloon	One B-57 sampler controller and one B-57 sampler
COLFAX	5 October 1958	500-foot well	One controller and one sampler took samples
TAMALPAIS	8 October 1958	Tunnel	No aircraft
QUAY	10 October 1958	100-foot tower	One B-57 controller and four samplers
LEA	13 October 1958	1,500 feet balloon	One controller and four samplers
NEPTUNE	14 October 1958	Tunnel	L-20 cloud tracker, only
HAMILTON	15 October 1958	50-foot tower	One B-57 controller and four B-57 samplers
LOGAN	15 October 1958	Tunnel	No samplers

Shot	Date	Type	Remarks
DONA ANA	16 October 1958	500 feet balloon	One controller and four B-57 samplers
VESTA	17 October 1958	Surface	One controller and one sampler participated
RIO ARRIBA	18 October 1958	70-foot tower	Four B-57 samplers and one controller
SAN JUAN	20 October 1958	300-foot well	One B-57 sampler controller and one B-57 sampler
SOCORRO	22 October 1958	1,500 feet balloon	Three samplers and a B-57 sample controller took part
WRANGELL	22 October 1958	1,500 feet balloon	Four B-57 samplers, one controller
OBERON	22 October 1958	25-foot tower	One B-57 sampler took part
RUSHMORE	22 October 1958	Balloon	One B-57 controller and two B-57 samplers participated
CATRON	24 October 1958	Tower	Three B-57 samplers, one as controller
JUNO	24 October 1958	Surface	One B-57 sampled
CERES	25 October 1958	Tower	No aircraft
SANFORD	26 October 1958	Balloon	One B-57 controlled and another sampled
DE BACA	26 October 1958	1,500 feet balloon	One B-57 controller and three samplers flew through the cloud

Shot	Date	Type	Remarks
CHAVES	27 October 1958	Tower	One controller and a sampling B-57 stood by
EVANS	28 October 1958	Tunnel	No samples
MAZAMA	29 October 1958	Tunnel	One B-57 stood by
HUMBOLDT	29 October 1958	50-foot tower	One B-57 participated
SANTA FE	29 October 1958	1,500 feet in balloon	One B-57 controller and one B-57 sampler
GANYMEDE	30 October 1958	Surface	No aircraft
BLANCA	30 October 1958	Tunnel	One B-57 controller and one B-57 sampler took part
TITANIA	30 October 1958	255-foot tower	A B-57 sampler control directed four B-57 samplers

During the last shot, TITANIA, the squadron flew newsmen through an atomic cloud for the first time.

PRIVACY ACT PROTECTED

MATERIAL REMOVED

said "Here we go" and as we did, the radiation needle shot up

SWEH-2-0034

208

AFWL/HO

the scale. As he completed the pass through the cloud, he banked so sharply for a second pass that the blood rushed from my head. We had pulled several times the force of gravity and my hands were frozen against my knees, but the right turn was a requirement to get back into the rapidly dissipating cloud.

Our second reading was five roentgens, the third was 2 1/2. In all we made about a dozen passes through the mass before Dr. Edward Flemming (University of California Radiation Laboratory sampler controller aboard the sample control B-57 airplane) told us to return to the base.

As we left the shot area, I threw a switch to close the butterfly valves on the wing tanks. We had obtained our samples of radioactive dust for the laboratories. The sleek jets touched down on the runway, and radiological safety officers prepared to remove us from the plane, without touching the "hot" sides of the craft. The samples from the wing tip tanks were also removed remotely.

and I were both given a thorough going over with a geiger counter. I was pronounced safe, but the pilot's hands were radioactive.

A little soap and water removed that hazard and we adjourned to the officers' club to collect our reward for beating the other two planes back to the base.

Pilots from the 4926th counted 88 cloud sampling sorties on 29 shots, with a total of 97 hours with B-57B samplers. On a number of shots, the squadron stood by only. During Phase II, the 4926th added a number of "firsts" to its record. Pilots sampled 29 shots within the short span of 49 days. On 22 October, the Squadron flew four missions on four different shots, three of which were full-scaled nuclear blasts. On 21 October, pilots performed the first night cloud sampling operation for the SANFORD Shot, making use of the clear sky and light from a full moon. Finally, for the first time, they flew through a cloud with three nationally-known newsmen.[21]

IX

Advantages of Experience

Concerning HARDTACK, Mr. Philip R. Moore, of Los Alamos, later explained why the B-57D aircraft was capable of obtaining samples safely which could not be gathered by other aircraft:

"It would be possible to get a sample from the stem of the cloud with a Piper Cub but you would soon have a dead pilot." Drawing a chalk chart on the blackboard of his office, Mr. Moore illustrated, " A B-57B for instance, would have to fly some 100 miles under the mushroom umbrella of the nuclear cloud to get to the only part it could sample--the stem. During that 100 miles, the pilot and plane would be receiving great quantities of 'shine' (radiation). The plane and crew would receive a duplicate dosage on the way back from under the cloud. A B-57D would be able to climb to the edge of the mushroom cloud, penetrate it for the sampling mission, bank and dive from the cloud upon completion of the mission and pick up only that radiation he started getting when he penetrated."[22]

But despite the availability of the B-57D, the Test Aircraft Unit was hard pressed to obtain sufficient pilots and observers to complete the series. Mr. Paul W. Guthals, also from Los Alamos, explained the situation:

> Early planning for HARDTACK called for 12 shots. By the time the series started, plans called for 24 shots. Before the series ended, a total of 33 shots were fired, besides the two in NEWSREEL. It was our biggest test

210

> series and although much good planning had been done, the additional shots upset the planning. The sampling crews used up their allowable radiation dosage and simply had to be replaced as they could not be used on any additional sampling missions. A sampling pilot is truly a sort of a super pilot--they're not easy to find. Then too, the shots often came so close together that the needed aircraft could not be allowed to 'cool off'--it had to be decontaminated immediately after landing from a sampling mission. This quick decontamination increased the replacement rate among the decontamination crews and men with less than the optimum decontamination training had to be used. Even with quick decontamination we occasionally could not have the proper plane for the mission in commission so had to substitute planes which were ready. This situation forced the B-57D aircraft to fly B-57B missions, thus speeding up the replacement of B-57D crews. Regardless of the importance of getting acceptable samples, the obtaining of samples is not worth the risk of excessive radiation to aircrewmen. Consequently, the pilots and observers had to be rotated.[23]

With the sampling element participating in all but two shots (TEAK and ORANGE), maximum radiation dosages were quickly reached by the sampler crewmen.

However, discussions with air sampling director, Paul W. Guthals, pointed out some of the difficulties of the operation.[24] "There must be a high degree of rapport between the LASL controller, the military controller and the sampling pilots. Time is so fleeting during a sampling operation, the controller and the sampling pilots have so many simultaneous tasks to accomplish that they must practically practice mental telepathy. The ~~mere~~ start of a sentence of instructions over the radio is often sufficient to achieve the maneuver change required. If full and complete instructions were required, time would be insufficient to achieve the maneuver. Dependable communications are an absolute must.

On earlier tests communcation failure occasionally occurred, and sampling pilots had to operate without control. Some were of such high calibre and competence that they managed to obtain acceptable samples in spite of the communication failure."

Concerning radiation dosage, Mr. Moore offered this comment:[25]

> Preplanning has always been so well done that the dosage to be received is known before the mission starts. The same for ground personnel and natives was not always true, although no serious and long-lasting illnesses have resulted from unplanned fallout or routine decontamination.
>
> But in our earlier operations, [redacted] established that we had been operating for years with a larger percentage of luck than we knew. Local wind situation has since been recognized as of extreme importance. Local winds fooled us [redacted] As well, [redacted] fooled us on fallout and yield. [redacted] the over-all weather had been predicted accurately, but the local winds blew fallout directly over the troop and operational areas. Fortunately it was not of sufficient intensity to require evacuation or extraordinary precautions. However, the weather people, after that incident, also forecast the local winds.
>
> Luck was also with us on another occasion. Of all the planes scheduled to participate on that shot, two aborted. Had they not aborted, they would have been directly over the detonation when it occurred.
>
> Again, great care was taken to package and return samples obtained to Los Alamos Scientific Laboratory with greatest possible speed and safety. Immediately the sampling aircraft landed, samples were removed, rolled into tubes and inserted into the lead "pigs" for their flight to LASL. Sample-carrying couriers were marked internally so that neither crew or passengers would get close enough to the pigs to receive more than one week's tolerance dosage during flight. Sample couriers flew straight through, with only a 20-minute stop at Hickam AFB, Hawaii, for refueling. Upon arrival at LASL, the samples were immediately removed from the pigs, placed in a solution of strong acids on a quartz flask in the "hot" chambers and filter paper and filtered material both completely dissolved. The resulting

solution was then divided and delivered to the various "specialists" who processed their portion of the solution to determine the exact strength of the substance for which they were testing. Preliminary readings were obtained, then more precise radiochemical processes applied, and the final exact findings were tabulated by automatic devices.

Decontamination of sampling aircraft remained a tremendous job throughout HARDTACK.[26] He recalled an attempt to obtain samples which proved to be costly both in man-hours and exhaustion of radiation levels. "On this attempt, I was in charge of securing the samples from a device buried at the point of detonation. Radiation levels were so intense that one hour was the limit for a man to work at the recovery site. We used 200 men, one hour each, to recover the sampling device. That experiment was another of the many which established that manned aircraft cloud sampling was the least expensive and most efficient."[27]

All aircraft returning to Eniwetok which could possibly be decontaminated were monitored and those requiring decontamination were isolated. Aircrews immediately processed through the decontamination center. When time permitted, aircraft decontaminated themselves in isolation through radioactive decay. This technique insured least radiation exposure to the decontamination personnel since the intensities approximately halved themselves each seven hours. After decay, the remainder of the contamination was removed from the aircraft through normal washing with chemicals, water and high pressure hoses. Through a conservative, yet realistic radiological safety program, Operation

HARDTACK was completed with no radiation injuries within Task Group 7.4.[28]

CHAPTER IX

NOTES

1. "History of the 4950th Test Group (N), 1 April 1957-30 September 1957," prep. by MSgt. William A. Evans, 4950th TG (N) Hist., 30 Sep. 1957, 1-3, in Hist. Div. files, Operation HARDTACK.

2. Ibid., 1.

3. Ltr., Dir., Wpn. Effects Tests, FC/AFSWP, to Cmdr., AFSWC, 10 June 1955, subj.: Forecast of Test Requirements, doc. No. 1 published in ibid.

4. Ltr., Brig. Gen. Perry B. Griffith, CofS, AFSWC, to Cmdr., FC/AFSWP, 26 Nov. 1956, subj.: Request for Information on Operation HARDTACK shot plans, see App.

5. "History of the 4950th TG (N), 1 April 1957-30 September 1957," 5.

6. TWX, 55434, CofS, USAF, to CINCSAC, et al., 29 Apr. 1957, see App.

7. Bk. Msg. 51415, CofS, USAF, to Cmdr., TG 7.4, and Cmdr., AFSWC, 11 Oct. 1957, see App.

8. 1st. Ind. (ltr., Lt. Col. R. J. Hynes, Dir. of Ops., 4950th TG (N), to Cmdr., AFSWC, 29 Mar. 1957, subj.: (C) Proposed Message from Headquarters USAF to Major Commands for Support of Operation HARDTACK), Maj. Cunningham, SWOTR, AFSWC, to Cmdr., 4950th TG (N), 3 Apr. 1957; Ltr., Cmdr., AFSWC, to Cmdr., n. d. (probably 9 June 1957), subj.: Proposed Book Message from Hq. USAF to Major Commands for support of Operation HARDTACK (C), see App.

9. Ibid.

10. TWX, C-12-502, CJTF SEVEN to CTG 7.1, LASL, et al., 25 Oct. 1957, see App.

11. See, following chapter on 4926th Test Squadron (Sampling).

12. Ltr., Col. W. B. Kieffer, Cmdr., TG 7.4, to Cmdr., 4951st Supp. Sq., (T), n. d., subj.: HARDTACK Planning Information, see App.

13. "History of REDWING/HARDTACK Interim Planning Period, 1 April 1957 to 30 September 1957," prep. by MSgt. Evans, 15-16.

14. Interview with Philip R. Moore, J-11, LASL, conducted by MSgt. Leland B. Taylor, AFSWC Hist. Div., 9 Sep. 1961.

15. "History of Task Group 7.4 in Operation HARDTACK, 1957-1958," in <u>Hist. of the AFSWC, 1 July - 31 December 1958</u>, 232-233.

16. <u>Ibid</u>.

17. <u>Ibid</u>., 287.

18. <u>Ibid</u>., 304-312.

19. <u>Ibid</u>., 361-362.

20. <u>Review-Journal</u>, Las Vegas, Nev., 31 Oct. 1958, in <u>ibid</u>., 384-386.

21. <u>Ibid</u>.

22. Interview with Mr. Moore, 9 Sep. 1961.

23. Interview with Paul W. Guthals, J-11, LASL, conducted by MSgt. Taylor, 12 Sep. 1961.

24. <u>Ibid</u>., charts which show the sampling aircraft participation in HARDTACK together with the value of the samples collected are included, starting on page 79 of "Final Report, Operation HARDTACK, Task Group 7.4" which is maintained in the AFSWC Historical Office files, "HARDTACK". Controlling of sampling aircraft during HARDTACK again required maximum resources, planning and skill. The details of controlling techniques applied are well recorded starting on page 122, "Final Report" HARDTACK, Task Group 7.4.

25. Interviews with Mr. Guthals and Mr. Moore.

26. <u>Ibid</u>.

27. <u>Ibid</u>.

28. <u>Ibid</u>.

CHAPTER X

NUCLEAR CLOUD SAMPLING

In the early days of sampling little was known about content of the cloud, the relationship between the content of the cloud and the efficiency or the yield of the nuclear detonation, nor the dangers associated with content of the cloud and "fallout." Along with cumulative experience, certain rules and formulae developed and cloud sampling became a prime means of judging the effectiveness of each device detonated. Three methods for determining efficiency evolved: cloud sampling, alpha measurement, and fire-ball measurements. Cloud sampling proved by far the most nearly accurate. Additionally, "tracer" elements were placed in the device itself to check the efficiency of the various components; however, sampling also gave the best readings from the "tracer" elements and provided a means of determining how well each integral part of the device functioned.[1]

Los Alamos Scientific Laboratory officials have discovered no accurate means of forecasting the behavior of a device. Testing furnished the only means of determining the efficiency of a device, and cloud sampling was the most nearly positive method for this. Secondary benefits from cloud sampling occurred in fallout sampling, identification of particles, cloud phenomenology, the distribution of fission products, and, sometimes, determining alien successes with similar devices.[2]

To provide the scientist a usable sample required three important conditions:

(1) It must comprise a large enough fraction of the total fission products and "unburned" material from the device to permit the desired measurements to be made reliably.

(2) The material which it comprised must be representative of the total bomb debris.

(3) The sample must not be cross-contaminated through debris from other tests.

Much of the debris remaining from a nuclear explosion drifted into the atmosphere as a cloud; therefore, it formed an attractive source for radiochemical samples.

As noted earlier, the collaboration between the Los Alamos Scientific Laboratory and the Air Force Special Weapons Center, established that cloud samples could most effectively be obtained through employment of piloted aircraft. Los Alamos officials established limits of gamma radiation exposure to the crew. In the United States, the limit was 3.9 roentgens of gamma radiation to the whole body within any three-months period and experience in sampling showed that, barring accidents, it was possible to collect satisfactory amounts of fission product debris well within this limit.[3] Atomic Energy Commission operated under the theory that such operations should be conducted with an "economy" of radiation exposure. On that basis, the amount of bomb debris to be collected could be specified in terms of the total radiation exposure required for the mission; that to be received in the cloud along with an estimate of that which would be received while the aircraft was returning to base. Through these relationships, it was possible to plan crew and aircraft requirements for an operation so that the 3.9-roentgen limit would not be excelled.

By 1956, studies of cloud rise, dispersion rates, and radiation intensities led to flight procedures and maneuvers which reduced risk of high exposure and consequently increased the proportion of flight time spent in the cloud when radiation intensities were low. The amount of radioactive debris collected relative to crew exposure had been increased through use of high-speed aircraft and the development of high-capacity filter units for these aircraft. Shielded flight clothing increased significantly the amount of material it became possible to collect. Finally, development of specialized instrumentation provided accurate operational control over radiation exposure during flight.[4]

Quantitative Considerations

In planning radiochemical experiments it was usually possible to determine how much post-explosion debris was required in a sample to perform these experiments and to express this requirement as a function of the predicted energy release. In the first place, a sufficient amount of the "unburned" components of the bomb were usually required to permit an accurate analysis for them in the presence of unavoidable amounts of these components, introduced by the collection medium or laboratory manipulations. In the second place, a sufficient amount of a radioactive substance formed in small quantity in the explosion might be required to permit its chemical separation and "counting" within acceptable limits of statistical error. Whether planning for a single nuclear test explosion or for a series of test explosions, officials needed to know whether piloted aircraft were capable of collecting the samples desired. An estimation of this capability and subsequent planning were based on:

(1) The characteristics of clouds from nuclear explosions which would afford an estimate of the sampling altitude required and the gamma radiation intensity within the cloud as function of time after burst.

(2) A quantitative estimate of the radiation exposure required in the cloud for the aircraft to collect the amount of material desired.

(3) A quantitative estimate of the additional radiation exposure to be received by the pilot on return to base.

These factors were discussed and related to the planning of a sampling mission.[5]

Characteristics of Clouds

From characteristics of bomb clouds, such as the height to which the primary material rose and the level and persistence of gamma radiation, personnel evaluated sampling capability in terms of the altitude capability of the aircraft available, the degree of risk to overexposure to radiation and the flight time in the cloud required to collect the sample. The sampling altitudes required were specified by the altitude interval in which the primary cloud was stabilized and, in general, comprised altitudes within this interval for which dispersal of the cloud by diffusion and wind shear was low. Fortunately, under visual flight conditions sampling participants easily recognized the primary bomb material by its reddish brown color in transmitted light arising largely from the presence of nitrogen dioxide, sometimes augmented by oxides of iron. In addition to these substances, the cloud was composed of condensed oxides of the fission products from the explosion, condensed oxides of the components of a nuclear device and associated equipment, and air. It also contained atmospheric dust from the air entrained during its rise. It could also contain dirt from the explosion site and condensed moisture. The latter components caused the primary cloud to appear white in reflected light but in such cases the interior was found to be suffused with typically reddish brown light.

The primary cloud was identified not only by its color but also by the presence of gamma radiation near or within it. Except for the radiation field in the free air outside the cloud and where material was too diffuse to be seen clearly, it was found nearly always that the color and radiation field occurred together. Many photographs of stabilized clouds from nuclear explosions clearly showed the reddish brown color of the primary bomb material lying uppermost, especially for the relatively low air burst. Below the main upper cloud, the color faded into the gray dust from the explosion site raised by the shock wave and vertical air currents in the explosion and cloud rise. For very high burst heights relative to yield the lower cloud material was unmixed with the dirt from the explosion site. In case of very low bursts considerable amount of primary bomb material might lay below the primary cloud but its color was masked by a high concentration of dirt. Because, in any case, this lower material could not be representative of the total explosion debris, sampling was usually conducted at altitudes within the main upper mass.[6]

X

Cloud Height and Sampling Altitude

Although a number of hydrodynamic and other phenomena accompanied a nuclear explosion, a few of the pertinent physical characteristics involved in the rise and stabilization of a cloud directly affected sampling techniques. The hot bubble of gaseous and particulate debris, remaining after explosion, had a temperature of several thousand degrees centigrade. This bubble displayed a large vertical acceleration because its density was much lower than that of the surrounding air. During the initial stages of its rise, a toroidal circulation (smoke-ring) usually formed in the bubble which for sufficiently high burst heights is markedly streamlined.

For bursts near the ground this circulation appeared to be disturbed by turbulence to a degree which was dependent upon initial burst conditions. As the stabilization altitude approached in the later stages of rise, this toroidal circulation weakened and eventually ceased to exist. By adiabatic cooling as the cloud rose through lower and lower atmospheric pressures and by the far more important process of entrainment of cooler air from the external atmosphere, the temperature of the ascending gas bubble fell rapidly. The temperature continued to fall until at some altitude the cloud attained density equilibrium with the external atmosphere. Momentum carried portions of it past the initial equilibrium altitude, but as adiabatic cooling continued the density of these portions became greater than that of the ambient atmosphere and their rise stopped. Subsidence occurred then to an altitude somewhat above the initial equilibrium point.

Because the cloud did not cool at the same rate uniformally throughout its volume, a vertical distribution of cloud material was observed at stabilization. In the simple case of an ideal, strongly streamline toroidal circulation of the outer portions of the cloud cooled more rapidly and stabilized at lower altitudes than the inner portions. Considerations of the surface relative to the volume of a cloud indicated that the altitudes of the top and base should be observed to be a power function of the yield of the explosion in a uniform atmosphere. Scientists frequently observed the temperature profile of the atmosphere above the tropopause, however, to be isothermal or sometimes to show a positive lapse rate, such as inversion. Clouds from higher yield explosions, therefore, had their rise strongly dampened by this temperature structure when they rapidly attained temperature equilibrium with the atmosphere above tropopause altitudes. The altitude of the primary mass of cloud material was related to yield. Scientific personnel made observations at the Nevada Proving Grounds of many explosions both at moderately high altitudes and relatively close to the ground, the range of burst height in most cases lying between 4,000-5,000 feet mean sea level. No attempt was made to correct for difference in height of burst for these data since particular atmospheric conditions such as temperature inversions, degree of wind shear, and humidity appeared to affect stabilization altitudes more than moderate differences in burst height. Because of these factors as well as the effect of the stratospheric temperature structure in the higher yield region, accurate determination of the yield of an explosion from the observed cloud height could not be determined. As previously discussed, some radioactive material could lay at lower altitudes. The distance below the primary cloud mass was in general, a function of the burst conditions, but usually the amount decreased rapidly with increasing distance.

Sampling aircraft with 45,000-foot altitude capability were suitable for the range yields and burst conditions discussed. For explosions with yields above 10 to 15 kilotons an aircraft of the B-29-type was considered marginal because of limited altitude capability. Such aircraft could only sample the lower portion of these clouds. An aircraft to sample the maximum altitude requirements foreseen was expected to operate sufficiently long at lower altitudes when required.[7]

Radiation Characteristics of Primary Clouds

While there were some activities derived from the neutron activation of nonfissionable bomb components, associated equipment, or dirt from the explosion sight, the major source of gamma radiation energy within the cloud derived from the fission products created in the explosion. Gamma radiation from this source decreased with time after burst.* The rate of decrease ~~of the~~ gamma radiation flux within the cloud reflected both the radiation decay source and the rate of decrease of the volumetric concentration of the source material as a result of cloud dispersal. Although the radiation intensity within an atomic cloud at shot times

*According to the familiar fission product decay law (Way-Wigner).

after burst received considerable theoretical study, the results were of little use for evaluating the radiation risk to piloted aircraft or the flight time within the cloud necessary to collect adequate samples at relatively late times after burst.

Scientific personnel measured the radiation within bomb clouds and reduced the data to equations. Such equations included intensity in roentgens per hour and this time in hours after burst and the numerical constant was the intensity observed one hour after burst. This curve represented the decrease with time after burst in "peak intensity" within the cloud. Such peak intensities are found in the most persistent layers of the main cloud at altitudes where isokinetic streamline airflow exists. In the absence of cloud dispersion similar equations expressed the decrease of the gamma radiation with time after one hour after burst as a result of the radioactive decay of the source material.

The first type equation served for operation planning purposes with the intensities within the cloud assumed to be independent of yield and altitude so long as sampling of the main cloud only was considered. A general rule which personnel applied to lower level sampling was that radioactive material and hence radiation intensity in the stem decreased in concentration tenfold for every 10,000 feet below the base of the main cloud when burst conditions were constant.[8]

Estimation of the In-Cloud Radiation Exposure Required

Within time limits defined by the radioactive intensity in a cloud the radiation exposure received by a sampling aircrew was controlled to any biologically accepted value. The ability to control this exposure, to predict the other flight variables, and to choose appropriate times for cloud penetration formed the basis by which sampling collection was conducted within an economy of radiation exposure. This economy was made quantitative through a relationship which expressed the amount of debris collected as a function of radiation exposure received and the other flight variables.

On a single penetration of a cloud from a nuclear explosion a sampling aircraft collected a total quantity of fission products and "unburned" debris determined by the total effective filtering rate of the filter devices which it carried, the volumetric concentration of fission products in the cloud, and the time of flight through the cloud. The crew of the aircraft received an exposure determined by the radiation intensity within the cloud (excepting radiation shielding structures in the aircraft) and the time of the flight through the cloud. The total effective volumetric filtering rate was proportional to the number of filter devices carried, the true airspeed of the aircraft, the area of the filter paper carried in each filter device, and the efficiency with which the filter paper retained the particulate matter. If the mass of concentration of inert material from the detonation was low the radiation intensity in the cloud was to a good approximation, proportional to the volume concentration of fission products, to the amount of radioactive decay which took place since the explosion, and inversely proportional to the air density at the altitude of penetration. Assuming that the radiation exposure received by the crew of the aircraft on approach to, and departure from the gamma radiation field in the free air surrounding the cloud was negligible and that the flight time for each penetration through the cloud was brief relative to the elapsed time since the explosion, scientists were able to formulate an equation to correlate the amount of cloud debris collected by a sampling aircraft with the radiation exposure received by the crew and with the other important flight variables. Quantitatively, the equation predicted that the amount of explosion debris collected was a maximum for a particular sampling aircraft, and its associated sampling equipment. Assuming equally effective filtering equipment and otherwise similar conditions, it indicated that a high speed aircraft collected more debris than a slow one in direct proportion to their relative speeds. It indicated, also, that the quantity of debris collected was not explicitly dependent upon the expected yield of a test explosion, but that the fraction of the total debris collected under given conditions was inversely (or hyperbolicly) dependent upon the yield. At early penetration times, therefore, a high radiation exposure was necessary to collect the required sample but if penetration time was delayed enough it was theoretically possible to collect any sample at a negligible cost of exposure. In addition, at too early a penetration time a serious risk existed in that an acceptable radiation exposure might be exceeded when the aircraft was in the cloud the least possible time. As penetration delayed, on the other hand, the cloud dispersed and the radiation flux within it decreased. Project officials met an increasing risk if delaying in that the cloud probably could not be identified and the required sample was not collected within the flight time available. Needed for planning purposes was an "optimum time" at which an acceptable radiation exposure would not necessarily or accidently be exceeded but at which it would always be possible to collect the required sample. Experience from a number of sampling missions established that these conditions were well fulfilled at two hours after burst for both jet fighter and bomber-type aircraft. Probable relative errors arose from uncertainties in the operational data (the chief uncertainty being in the radiation exposure used which is determined by film dosimetry) and the approximations used in its calculation. Although the above values were equal within the probable relative errors, the observed small difference between them was due to the location of structures with better radiation scattering properties closer to the pilot in the fighter-type compared with structures located near the average crew position in the bomber-type aircraft.

With known constants, it was possible to obtain good approximate evaluations for any type aircraft carrying any type of filter papers and to find values in advance of operational use. For particular aircraft and associated filter devices it was sometimes convenient to express equations in the form of the curves shown in which the amount of explosion debris collected was a function of cloud penetration time for the two types of aircraft discussed. The curves were based upon altitudes and indicated airspeeds at which the aircraft were frequently used (25,000 feet and 200 miles per hour for B-29, and 35,000 feet and 300 miles per hour for the fighter-type) as well as upon a reference in-cloud exposure of 1.0 roentgen.

Since any penetration time was directly proportional to the in-cloud exposure and since suitable proportional corrections could be made for different sampling altitudes and airspeeds, curves were used to determine quickly either sampling capability or required in-cloud exposure.

It was assumed, for example, that sampling missions were to be planned within a limit of 3.9 roentgens total radiation exposure using F-84G aircraft for two nuclear explosions having predicted yields such that the sampling altitude was determined to be 35,000 feet. Typical requirements were as follows:

(a) For the first explosion each sample should contain on the average, an amount of material (FE) equivalent to 1×10^{-8} kilotons.

(b) For the second device the smallest sample size should average 1×10^{-7} kilotons and this amount should be exceeded if possible.

(c) For each explosion should be expected differences in the amount collected by individual aircraft from that required if these differences were within the probable relative error.

Since the probable sampling altitude assumed was that used for the F-84G curve, it could be used directly to determine the in-cloud exposures required for these missions. At the two-hour "optimum" penetration time, simple proportion indicated that 0.175 roentgen was required to collect the sample for the first test while 1.75 roentgens was required to obtain the minimum amount desired in the second explosion. The total in-cloud exposure for both missions was the sum of these exposures or 1.925 roentgens.[9]

Radiation Exposure Received During Return to Base

Although the above illustrated that fighter-type aircraft were capable of collecting the desired samples from two explosions within the acceptable limit for the in-cloud radiation exposure, a complete estimate of capability included additional exposure received while the aircraft was returning to base. During the flight through a cloud some of the radioactive debris adhered to the exterior surfaces of the sampling aircraft. As a result a radiation flux or "cockpit" radiation background existed within the interior of a sampling aircraft after its departure from the cloud. While returning to base the pilot received additional radiation exposure. Since this exposure decreased that which was available for collecting a sample, it was important to understand what factor contributed to it and to be able to estimate what increases over the in-cloud exposure project personnel might expect under operational conditions. Such an increase was especially significant when the in-cloud exposure was required to be high and the time to return to base of long duration.[10]

To Los Alamos scientists the retention of radioactive material on the surface of the aircraft appeared to depend markedly upon the location of the surface, its state of cleanliness, the mode of airflow over it, and the state of aggregation of the contaminating radioactive debris. While the phenomena involved in the retention of the material were somewhat complex, all of the surfaces taken together were considered as a collector similar to the filter devices carried by the aircraft. For short flight times in the cloud, therefore, the amount of material adhering after a single cloud penetration was determined by an equation similar to that used for radiation exposure from in-cloud flights.

Some Observations On Technique

A terse, all-inclusive instruction concerning need for sampling operations and requirements was restated in preparation for Operation TRUMPET.* In a memorandum for the Director of Research and Development, Air Force Special Weapons Center, Captain A. B. Gordon, Assistant Executive AFOAT-1, stated, "It is planned that debris from each detonation will be analyzed by AFOAT-1. Analysis of debris will provide calibration data for use in diagnostic evaluation of nuclear devices and weapons; special studies of analytical techniques."[11] He continued,

> It is anticipated that close-in sampling will be conducted by the 4926th Test Squadron (Sampling) under the technical supervision of a representative from either UCRL, LASL or other sponsoring agencies. Representative samples of particulate debris from each shot would be supplied to McClellan Central Laboratory by UCRL, LASL, or other shot sponsors within approximately 48 hours of shot time. It is expected that the following types of samplers may be required:
>
> (1) Close-in air filter samples by use of aircraft for all U. S. events.
>
> (2) Fall-out and crater samples for surface or near surface detonation of low yield devices (less than 00 KT).
>
> Gas samples will be collected by the 4926th Test Squadron (Sampling) under the direction of LASL and UCRL representatives. Sample analyses will be performed by laboratories under contract to AFOAT-1. It is probable that samples will be required from no more than ten shots.

---

*Operation TRUMPET was in planning stages at this time, February 1958. It was expected to follow Operation HARDTACK.

Control of aircraft during sampling operations required exactness and pilot coordination considerably above the level of otherwise competent pilots. According to Mr. Paul W. Guthals of Los Alamos,

> Pilots with the ability to succeed in sampling missions were difficult to find. It was necessary for them to be adept at piloting under unusual, dangerous, and difficult conditions. Additionally, they had to possess the ability to receive radioed instructions, make taped recordings of instrument readings, be alert for excessive radiation and a myriad of other details simultaneously.
>
> I remember during the OAK event, a field grade officer, command pilot, volunteered to get an early sample [redacted] It was his first sampling mission. As he entered the cloud, he, in a normal voice, reported an "R" reading of 30. In rapid succession his "R" reading reports came over the radio--each report higher in radiation intensity and each report in a voice of higher pitch. As his instruments passed 100 roentgens per hour readings, his voice was pitched so high that it didn't seem possible that a man was transmitting.
>
> Of all the sampling pilots employed, to my knowledge, was the only one who was not a command pilot. Most pilots with less experience and proven ability were simply overwhelmed--so badly that they could not function satisfactorily--by the awesomeness of the cloud interior.[12]

Sampler pilots and controllers found detailed requirements and methods given in "Control and Sampling Procedures for Eager Beaver Aircraft."[13] They found instructions for air filters used, the bags for collecting gas samples, and a discussion of water samples in "Sampling Methods."[14] These instructions were incorporated in operation planning for the squadron.

In 1953, an earlier approach to determining yield was directed toward the collection of valuable material from the contaminated aircraft itself. In this test, scientists sealed the decontamination pod with a plastic compound, washed the contaminated aircraft with citric acid solutions, and barreled the resultant liquid for analysis by radio chemistry scientists.[15]

During Operation IVY, a pilot recorded these sensations as he penetrated the MIKE cloud,

> Sampler Element Commander, led the first flight of four samplers, code name RED flight, and was first to enter the towering MIKE cloud. The bottom of the flat part of the mushroom-shaped cloud was estimated at 55,000 feet by the "Sniffers." So, RED flight could only enter the stem of the mushroom. The first penetration was made at near maximum altitude of 42,000 feet. was vectored from directly over the B-36 Control aircraft to enter a small segment extending from the stem of the cloud at approximately H plus one hour forty minutes. He and his wing man turned and flew toward the cloud for 15 minutes before making contact with it. Apparently the cloud was so massive that, although the controller aircraft seemed to be quite close to it, it was approximately 100 miles away. Upon entering the cloud, each pilot was going to be well occupied. First he had to fly the airplane on instruments. Then he had three radiation instruments to watch, remembering critical information so that he could report it to the scientists in the control ship and jot it down on his report sheet. And he had a stop watch so that he could time his stay in the radiation over one roentgen in intensity. Immediately upon entering the cloud, RED Leader was struck by the redness of the cloud. It cast a red glow all over the cockpit. His rad-instruments "hit the peg." There was no way of knowing how much hotter it actually was than the capacity of his instruments. The hand on the integron which showed the rate at which radioactivity was being accumulated, "went around like the sweep second hand on a watch . . . And I had thought it would barely move!" Seeing "everything on the peg" and the red glow like the inside of a red hot furnace was staggering and quickly made a 90° turn to leave the cloud. When he came out, his stop watch showed that he had spent five minutes in radiation over one roentgen. He reported to "DOG-2," the Control B-36, collected his wing men and then it was time for RED-3 and RED-4 to enter the cloud. RED Leader cautioned them not to go in too far and they disappeared into the cloud. Apparently from subsequent events, RED-4, spun out

> shortly after entry into the cloud. RED Leader heard heavy breathing over the radio as someone inadvertently held their mike button down. Then called, saying that he had "recovered at 20,000 feet." instructed RED 3 and RED-4 to get together and return to the B-36 and the tanker for refueling. After acknowledging, RED-3 and RED-4 were switched to another radio channel for rendezvous instructions from the Control B-29, and did not hear the remainder of their story.[16]

In 1953, Dr. Alvin C. Graves, Los Alamos Scientific Laboratory, issued a directive which detailed sampling techniques and requirements of the laboratory over the next several years. Dr. Graves predicted correctly that techniques and requirements would not change much even though sampling moved in the direction of higher altitude performance and longer flight time capabilities at altitude. He foresaw no drastic changes in the filter equipment, power requirement, aircraft instrumentation, and support aircraft, only a refinement and sophistication would be acquired through experience. Some of these techniques as worked out by Los Alamos officials were:

1. <u>Sampling Description</u>:

1.1. Filter Samples:

1.1.1. Filter samples of the type presently collected will be required. It is most probable that the filter unit will be designed within the shape of an acceptable store already designed for use with an available aircraft.

1.1.2. Depending upon the size of the external store, the filter unit will contain a filter panel with between 2 and 4 square feet of paper. Depending upon the internal fuel capacity of the aircraft, the filter unit may or may not contain fuel.

1.1.3 Power comprising 28 volts d.c. at ten amps, and 110 volt 400 cycle a.c. at 5 amps should be available to operate relays, butterfly valves and sample radiation monitoring equipment which will be used with the filter unit. Suitable wiring to the filter unit will be required.

1.1.4 Depending upon the configuration of the aircraft used and clearances between the wing and the ground, the filter unit may be mounted either on the wingtips or on pylon position underneath the wings. Ordinarily it would be desirable for an aircraft to carry two filter units.

1.2 Gas Samples:

1.2.1 Snap-type Samples.

1.2.1.1 The polyethelene bag snap-type equipment will be required and should have a capacity of 15 to 100 cubic feet at the sampling altitude. The auxiliary power requirements should be negligible, but wiring will be required to carry power for the relay valves opening and closing the bag.

1.2.1.2 This equipment should be located in a space within the fuselage of the aircraft. An external air sampling probe leading to the sampling apparatus will be required.

1.2.2 Pressure-bottle Type:

1.2.2.1 It is anticipated that a pressure-bottle type of gas-sampling apparatus similar to that being developed for the F-84G's will be required as an alternative to the bag type. The physical size and power requirements for this type of apparatus will be similar to those for the system being designed for the F-84G.

1.2.2.2 This apparatus should be installed in suitable space within the fuselage of the aircraft and will require an external sampling probe.

2. Desired Sampling Altitudes:

2.1 The desired sampling altitude will depend upon the yield of the detonation and the burst height but, in general, will range between 10,000 feet MSL to the maximum altitude attainable. It would be desirable for the sampling aircraft to have a routinely attainable maximum altitude of at least 60,000 feet. It should be mentioned that, if space requirements for gas sampling equipment are incompatible with the configuration of a particular aircraft with excellent altitude performance, we would like to reconsider the space requirements.

3. Estimated Endurance At Desired Altitude:

3.1 The flight time required at any altitude is a function of the radiation exposure required and the radiation intensity in the cloud. A flight time capability of one and one half hours, exclusive of the time required for arrival and departure and rendezvous at the sampling area, should suffice to fulfill any normal radiation exposure requirements. The minimum time exclusive of maneuver requirements, should be taken as twenty minutes.

4. Number of Samples Desired:

4.1 A maximum of six samples will ordinarily be required. If the filter units carry approximately the same area of filter paper as the F-84G units, six samples will correspond to twelve aircraft which should be operational at all times. If a larger aircraft is used, which can carry double the amount of filter paper, six aircraft would be required. Sufficient spare aircraft to insure this operational capability should be available. It may occasionally be desirable to use all aircraft, including spares, which are in operational order.

5. Aircraft Instrumentation Desired:

5.1 The sampling aircraft should carry the following radiation instrumentation:

5.1.1 Airborne gamma radiation dosimeter with a maximum exposure range of 7.5 roentgens.

5.1.2 Airborne radiation rate meter with a range between .05 and 500 r/hr.

5.1.3 Sample radiation monitoring instruments including electronic components and controls.

5.2 These instruments should be located in the aircraft in a position similar to that in the F-84G. They will have suitable response times, food responses to a wide spectrum of gamma radiation energy, and suitable pressure and humidity characteristics. They will probably be comprised by the instruments presently furnished for sampling purposes.

6. Approximate Radius of Operation of the Aircraft:

6.1 The radius operation for sampling is dependent upon the wind velocity at the sampling altitude, the time of cloud penetration, and the test site geometry. The most probable radius of operation is 300 miles but under certain circumstances may attain 400 miles.

7. Aircraft Required to Support Sampling Missions:

7.1 For continental shots the capability of the B-50D is adequate for a control aircraft.

7.2 For the high yield shots in the Eniwetok Proving Ground area the control aircraft should have a capability of at least ten hours total flight time, eight of which must be spent at 45,000 feet. The control aircraft should have space for the normal crew plus at least two spaces for control personnel. If this aircraft has a speed capability of approximately 0.8 mach it may be possible to perform some of the early reconnaissance operations with it instead of with one of the sampling aircraft.

7.3 Courier aircraft support similar to that now required for Nevada and Eniwetok Proving Grounds shots will be required.

8. Special Equipment Needed in Support Aircraft:

8.1 Inter-communication, VHF communications and homing equipment now required for control aircraft will be needed in the future. Sufficient space should be available for radiation monitoring instruments which will be carried during the control flight.

9. Flights Desired Between Scheduled Tests:

9.1 Flight tests for the evaluation and calibration of special equipment may be required from time to time between tests. It is estimated that ten three-hour missions will be required during the year.

10. Other Technical Data:

10.1 The airspeed of the sampling aircraft should be approximately 0.8 mach. Should they become available, it may be desirable to make special use of aircraft with altitude, range, or endurance capability superior to the standard sampling aircraft.

10.2 The sampling aircraft should be provided with a filtered pressurization system so that the aircrews may fly pressurized and should be equipped with lead shielding in the seats. Aircrew personnel should wear the special shielded flight clothing which has been developed for the present sampling missions.

10.3 It is highly desirable, in addition, that the aircraft carry at least two flight personnal. By freeing the pilot to attend to his normal flying operations, a second person should contribute greatly to the effectiveness of the mission.

10.4 There is evidence that an airduct configuration such as that of the F-84G approximately doubles the radiation intensity in the cockpit acquired during cloud penetration. In order to reduce radiation exposure received during return to base, an effort should be made to choose an aircraft for sampling which has engines and air-ducts well removed from the crew compartments.

11. General.

11.1 While drone aircraft support for sampling purposes is not directly required, we wish to restate our desire to take advantage of such type aircraft if required for other agencies provided it is feasible operationally and equipment-wise to do so.[17]

A sustained, major consideration for carrying out sampling programs involved changing organizations and responsible personnel who had no experience with this type of work. In February 1956, Dr. Harold Plank composed a "how to do it" document for submission to the Task Group 7.4.

It covered installation and removal of filters during sampling and warned that "this SOP must be considered as provisional because experience with the B-57B unit in the field does not exist."[18] His instructions ran as follows:

1.0 Materials, tools, vehicles, and personnel required.

1.1 Materials. Pre-cut filter paper for F-84G and B-57B filter units, aircraft safety wire, 36 inch roll heavy wrapping paper.

1.2. Tools.

1.2.1 Assembly tools. Side cutters, long-nosed pliers.

1.2.2 Removal tools. Long-handled side cutters, 9 foot removal pole, long-handled tongs, long-handled wire puller, long-handled paper roller tool, long-handled instrument adjusting tool, long-handled hooked carrying pole for filter paper containers, box shielded with 1/4 inch lead sheet for empty filter holder scrap tie wire, rack for removal tools, shielded V shaped "cave" for rolling filters, shielded filter paper carrying cases (pigs).

1.3 Vehicles. Two (2) low bed, rubber-tired trailers, in tandem towed by truck or tug; one (1) low bed, rubber-tired trailer pulled by truck or tug.

1.4 Personnel. Two (2) airmen, one (1) officer for direct removal operations, plus one (1) overall supervisor.

2.0 Assembly and Installation.

2.1 Assembly.

2.1.1 Pre-cut filter is laid into clean filter holders with care taken to assure good overlap of frame edges by filter material. Caution: Cloth scrim must be laid next to small mesh ($\frac{1}{4}$in.) wire of aft frame of holder; reject filters which have badly ravelled or separated scrim at edges. Holder is then closed and safety-wired as required. Caution: Hands and working surfaces must be surgically clean to avoid undesirable contamination of filter materials during preparation. Holders should be identified by aircraft number and side with ink marking pen on forward half of holder outer frame. Assembled paper and holders may be stored by carefully wrapping in clean heavy paper sealed with tape to be dust-tight. Outside of package should be marked to identify contents. The serial number of filter holder and aircraft in which installed should be permanently recorded for each shot with copy to 11.2 Project Officer.

2.2 Installations.

2.2.1 In general, filter holders may be installed the evening before shot time, but if delay seems probable or weather is very rainy, holders should be installed at last convenient moment. Caution: Moisture greatly weakens the filter material. Before installation of holder, filter unit should have been thoroughly decontaminated, rinsed with pure water, and dried. After being cleaned, it should be kept clean by use of plastic cover or tape covering inlet hole and exit slot. Cover should be kept on after holder has been installed to prevent contamination until just before take-off when airplane is in take-off position. Caution: Pilots should avoid taking-off in jet blast or exhaust of preceding aircraft. Holder is inserted with 1/4 inch mesh positioned to the aft side of slot in unit. Care must be taken to insure that filter material does not move down from supporting frame edge because filter failure will result. Holder should be inspected through exit slot for such movement of paper. After insertion, holder is fastened with safety wire across slot in the case of the F-84G airplane or by closing stress latches on the B-57B unit. Caution: Do not pinch or cut wire on F-84G unit or it may fail and filter holder may fall out on landing roll. Caution: Stress latches on B-57B unit must be carefully adjusted or they may open on take-off or landing and holder may fall out. If filter unit is flown at high speeds with latches open structural failure may result.

3.0 Removal.

3.1 Preparation.

3.1.1 Aircraft Parking.

3.1.1.1 To expedite removal from parked aircraft the aircraft should be parked so that access to wing tips and positioning of removal vehicles can be done without penetrating parking array; i. e. aircraft should be parked in line on taxi-way wing tip to wing tip, if possible, spaced 25 to 50 feet apart; they should not be parked in a three-line box array, for example.

3.1.1.2 Alternative to 3.1.1.1 samples can be removed from airplanes one at a time when they are enroute to parking area towed by tug after crew has been removed. This method was used for F-84G aircraft in CASTLE: samples were removed near AEC compound at entrance to old drone aircraft parking area.

3.1.2 Personnel. All personnel concerned should wear fatigue type clothing, including cap, high-top heavy field shoes and leather palmed work gloves. Properly executed removal operations should not result in contamination of personnel.

3.1.3 Vehicles and Tools.

3.1.3.1 Truck or tug with two trailers in tandem; shielded box for empty filter holders is placed at front of first trailer next to tug, removal tools and rack placed next to box, tools resting with heads in rack; shielded cave is placed in rear of second trailer with filter paper pig tray toward forward end; plywood liners are placed in cave and calibrated T-1B or AN/PDR-39 is installed in rack under pig tray. Tug and trailers are positioned 25 to 50 feet in front of airplane so that last trailer is in front of airplane.

3.1.3.2 Truck or tug with one trailer; unfilled pigs with boxes are placed to front of and boxes for filled pigs are placed at rear of trailer. Truck and trailer are positioned in front of airplane with trailer 25 feet from second of above trailers and trucks faced in opposite directions.

3.1.3.3 Empty pig is marked with identification symbols and placed in tray on "cave."

3.2 Operations.

3.2.1 Three personnel directly engaged in removal operations are designated by number and duties as follows:

3.2.1.1 Number one (1) primarily cuts the wire or unlocks stress latches to free filter holder.

3.2.1.2 Number two (2) primarily pulls holder from filter unit and carries it to cave.

3.2.1.3 Number three (3) primarily rolls paper and inserts it into pig.

3.2.2 Freeing Filter Holders. With vehicles positioned near aircraft as described above and with proper tools in hand, numbers one and two take initial positions side by side between trailer and aircraft at least 25 feet from filter unit. Number one advances to unit, cuts wire or opens latches and returns to tool trailer after making sure holder will not fall out of own accord. He places cutting or opening tool in rack, takes up long-handled tongs and returns to initial position by number two.

3.2.3 Removing Filter Holder. Number two advances to unit, inserts hook on removal pole into ring on holder and pulls gently to withdraw holder. Caution: Number two must be ready to prevent holder from striking ground as it leaves filter unit. Number one stands by at initial position to assist in recovery of holder if for some reason it should fall to ground from pulling pole or to recover paper if it should fall from holder. (Note: None of these events are likely because of the basic design of holder and pulling tool.) When holder is securely on pole, number two carries it with pole at angle about 30° above horizontal to cave trailer and deposits it therein. Caution: Higher angle may result in personnel contamination from debris falling from filter. Filter should be carried down wind, if possible. Number one returns long-handled tongs to tool rack, takes up safety wire hook tool and takes position on opposite side of cave from number two.

3.2.4 Rolling and Packaging Filter Paper. While holder is restrained by number two with removal pole, number one pulls safety wire from holder rim, drops wire in shielded box on tool trailer and returns tool to rack. Number one disengages pulling pole hook from holder, spreads holder for number three to insert paper rolling tool over paper, then returns pulling pole to rack. During rolling operations, number one and two stand well clear of cave, aircraft, and other radiation sources. Number three rolls paper with tool, inserts it into pig, and withdraws to safe distance after placing tool in rack.

3.2.5 Removal of Pig. Number one now measures radiation intensity through pig, adjusting instrument by means of long-handled tool for purpose. Reading, time and sample identification are recorded with original to 11.2 courier and copy to 11.2 Project Officer. After this measurement, number one returns tool to rack. Numbers one and two now take up pig carrying pole, each on opposite sides of trailer, lift pig from tray on "cave." Lid of pig will close and lock automatically. Pig is carried to box trailer and placed into proper section of box. Carrying tool is returned to tool rack.

3.2.6 Filter holder is removed and filter packaged from other side of aircraft in similar manner.

4.0 Duties and Information for Overall Supervisor.

4.1 Duties.

4.1.1 Overall supervisor must keep constant watch to see that personnel do not inadvertently remain for long times close to high intensity sources of radiation such as filter units, "cave" with filter paper in it, box with empty filter holders and scrap safety wire, or filled pigs on trailer number three. He must monitor positions of personnel relative to each other and their handling of removal tools so that "hot" tools do not accidently touch personnel. He must insure that casual observer personnel do not get in way of removal operations. In case of accident or equipment failure, supervisor must determine appropriate action to be taken. Caution: In no case is it permissable for personnel to use their hands (even protected by leather palmed gloves) to restrain or maneuver "hot" filter paper.

4.2 Information.

4.2.1 A single filter paper from a B-57B aircraft may frequently have a gamma radiation intensity of 100 r/hr at one foot. At 25 feet the background radiation intensity from this source alone will be approximately 0.5 r/hr. Distances from aircraft for trailer and for personnel positions must be chosen as compromise between high background radiation and time required for critical operations such as carrying the filter in filter holder from airplane to cave. The success of removal operations as described above represents compromises between protection by shielding or by distance from source and time required to perform operations swiftly and safely. The basic philosophy underlying this operation, as for other phases of sampling, is that radiation exposures will be held to the minimum practicable to accomplish the job.

In general, Los Alamos scientists held that once experienced personnel were transferred or disbanded, the task for rebuilding a sampling unit would be difficult if testing resumed after sporadic periods. The function was unique and existed for highly specified conditions. Of necessity, many personnel entered the work with little or no knowledge of testing or what the above entailed.[19]

CHAPTER X

NOTES

1. Interview with Paul W. Guthals, J-11, LASL, conducted by MSgt. Leland B. Taylor, AFSWC Hist. Div., 20 Sep. 1961.

2. Ibid.

3. Ltr., Gordon L. Jacks, Cmdr., TG-7, to William E. Ogle, TG-7, 23 Oct. 1955, subj.: Dosage Limitations for Aircrews Flying for Hal Plank, see App; "Operation UPSHOT/KNOTHOLE, Nevada Proving Grounds, March-June 1953, Report to the Test Director: Aircraft Participation," prep. by Col. Paul H. Fackler, 4925th TG (A), Nov. 1955, 17-18, see App. The maximum allowable exposure per person for one entire operation was set at 3.9 roentgens by the Chief, Biological-Medical Division, AEC; Ltr., Harold F. Plank, Asst. Gp. Leader, J-11, to Cmdr., 4950th TG (N), 10 Oct. 1956, n.s. A survey of correspondence relating to operations, continental and overseas, reveals concern of Air Force officials to keep individual exposure below 3.0 roentgens, at least, for the specified times.

4. Rpt., "Sampling Radioactive Clouds from the Explosion of Nuclear Devices," prep. by Dr. Plank, see App. This document was intended for use by the British and explains sampling problems as understood by Los Alamos scientists at that time.

5. Ibid., 5

6. Ibid., 6-7

7. Ibid., 7-10

8. Ibid., 10-11

9. Ibid., 11-18. This section presents all the fundamental equations in detail.

10. Ibid., 18-19

11. Memo. for Dir. of R&D, DCS/O, prep. by Capt. A. B. Gordon, AFOAT-1, 21 Feb. 1958, subj.: Operations and Training Programs for Participation in Operation TRUMPET, see App.

12. Interview with Mr. Guthals, 20 Sep. 1961.

13. Ops. Plan, "Control and Sampling Procedures for Eager Beaver Aircraft," (prep. by TG 7.4 personnel) n.d., see App.

14. Ibid., App. I, Sampling Methods.

X

15. Ltr., Duncan Curry, Jr., LASL, to Lt. Col. James Crosby, CTG 7.4, 21 Dec. 1953, subj.: Recovery of Valuable Material from Contaminated Aircraft, see App.

16. Rpt., "Air Task Group Participation in MIKE Shot, 1 November 1952, Operation IVY," prep. by Capt. C. C. Gorham, Hist. Off., Nov. 1952, 7-8, see App.

17. Ltr., Dr. Alvin C. Graves, LASL, to Cmdr., AFSWC, 9 Dec. 1953, subj.: Sampling Needs Through Fiscal Year 1956, see App.

18. Ltr., Plank, LASL to Cmdr., TG 7.4 (P), 15 Feb. 1956, n.s., see App.

19. Interview with Mr. Guthals, 20 Sep. 1961.

CHAPTER XI

RADIATION PRECAUTIONS

With a universal fear of the unknown dangers of radiation resulting from nuclear detonations, officials associated with the tests concentrated on developing handling techniques which would not endanger the lives, well-being, or generic values of those participating. As brought out in earlier chapters, the fear of the effects of the nuclear cloud prevented the use of manned aircraft as samplers during several tests. Following "accidental" penetration of a small segment of an atomic cloud, radiac officials decided that such penetrations would not necessarily result in a lingering and horrible death. Consequently, a cloud penetration program evolved which was utilized with apparent safety.

Within a few short years, sufficient knowledge had been accumulated concerning the awesome contents of a nuclear cloud so that sampling by manned aircraft became nearly as routine as ordinary flight. Colonel Karl H. Houghton, summarized the progress in a memorandum to Deputy Chief of Staff, Operations, on 21 August 1953:

"Another point which might be of interest to the listeners is that historically, manned sampling has grown from a random approach at Operation RANGER and GREENHOUSE to one in which sample quantity-quality can be predicted and controlled by time and length of flight, positioning in the cloud, and the extent of radiation exposure allowed the pilot. The true cost of operation is measured in terms of radiation exposure to the pilot. Pilot exposure is the limiting factor on quantity of sample obtained."[1]

The Air Force conducted several such studies in order to formulate standard operating procedures for the 4926th pilots and maintenance crews. Probably the most significant was that directed by Colonel Ernest A. Pinson and published by the Special Weapons Center in June 1956.[2] The report analyzed radiation dosages received while passing through the visible cloud and those received subsequent to exit and returning to home base. Evaluations were rendered for T-33, F-84, B-36, and B-57 aircraft. Project officers found the contamination to be higher for fighter than for bomber aircraft, unclean aircraft collected more radiation than clean. Grease spots collected more than 100 times as much contamination in passage through a radioactive cloud as a clean surface of equal area. Colonel Pinson was able to compose an equation showing radiation dose received by aircrews with the following known factors: penetration time in minutes after detonation, aircraft landing time in minutes after detonation, yield in megatons, contamination factor in reciprocal minutes, and aircraft speed relative to cloud in kilofeet per minute. However, Air Force officials believed the equation accurate within plus or minus 65 per cent for nominal yield bombs. A scarcity of information on the dimensions of and radiation intensity in clouds from megaton devices at operational altitudes for times up to one hour after detonation made "the prediction of aircrew radiation doses in transit through such clouds questionable."[3]

The enforcement of radiological safety measures, however, was a continuing problem, with outright rebellion by Air Force operational leaders threatened on at least one occasion. They argued that no serious mishaps had occurred and that application of accepted radiological safety measures unnecessarily upped the requirements for manpower, lessened the readiness of crews and aircraft for tests and that the entire decontamination program was more than actually required to insure safety.[4]

Officials of the Los Alamos Scientific Laboratory took exceptions to Colonel William B.Kieffer's proposed changes to their equally cautious safety procedures, and resulting correspondence recorded a thorough disagreement and conflict between the nuclear scientists and operational people. In early March, 1957, Harold Plank wrote:[5]

"For workers who are occupationally exposed on a year-round basis, it is expected that the total non-medical exposure to gamma radiation will be limited to five roentgens per year with a general requirement that the exposure up to the age of 30 years be limited to fifty roentgens and that no more than fifty roentgens be received in each subsequent decade. It is understood that these restrictions are motivated by concern for the genetic effects of radiation throughout the population at large rather than by considerations of effects on the health of the exposed individual." He then laid down the limitations for the then planned tests, PILGRIM, TRUMPET, and HARDTACK.

> We would like to propose that the sampling pilots for PILGRIM be restricted to 3.9 (plus or minus 10 per cent) roentgens but that, whenever possible, the actual exposures be limited to 2.4 roentgens. A prudent alternative which would minimize the pilots required for PILGRIM, would be to observe an actual limit of 3.9 roentgens on PILGRIM, bring these persons to a yearly total of five roentgens during TRUMPET, and meet the balance of the TRUMPET requirements with new pilots. Each of these new pilots would be allowed five roentgens. The number of new pilots needed might be

> based also upon the augmentation which may be required for HARDTACK, so that at the end of TRUMPET you would have a fully trained complement for that sampling mission. If we observe prudent limits of exposure during 1957, I believe that we would be justified in requesting the 'ten roentgens permissible -- twenty roentgens emergency' exposure ordinarily required by a series of high field detonations at the Pacific Proving Ground.

But somewhat later, on 21 March 1957, Colonel Kieffer, then Deputy Commander for the Special Weapons Center, took exception to the guide lines laid down by Dr. Plank:[6]

> Studies conducted on Operation TEAPOT and REDWING, however indicate that the benefits obtained from decontamination are not worth the effort and material expended. Over 95 per cent of the pilot dosage is accumulated while sampling and during the return flight. As far as total pilot exposure is concerned, the radiation intensity in the cockpit as a result of contamination accumulated on previous events is negligible. Moreover, 50 per cent or more of the cockpit intensity is contributed from the contaminated engines in the F-84G and 25 per cent or more from the engines on the B-57. Jet engines cannot be decontaminated in the field.
>
> Since a minor portion of the maintenance is on or near the engine -- which cannot be decontaminated -- it would appear that the effectiveness of decontamination in reducing exposure to maintenance personnel is limited.
>
> At TEAPOT the average accumulated dose to maintenance personnel was less than 1 r. The maximum individual dose was approximately 1500 mr. If a reduced decontamination effort doubled this average dosage, the 300 m/r or 3.0 r test limit would still be met. The figures shown on the Aircraft Decay and Decontamination Chart indicate that aircrews would receive an incremental dose of less than 5 per cent if decontamination were not performed.

The above average was not the first, nor the last, concerning reduction of safety measures. On 29 July 1954, Colonel Karl H. Houghton, Acting Deputy Chief of Staff for Research and Development, suggested that the problem of attaining cleaner surfaces on sampling aircraft be investigated. His ideas proposed that having the surfaces of the anticipated sampling B-57 aircraft painted or permeated with a protective substance at the factory might be an answer to the contamination problem. So he wrote to the Deputy Chief of Staff, Operations,[7]

> . . . A rough dirty surface allows a large build-up of contamination material with a proportional increase in the background radiation to which the pilot is subjected on the return flight. We have attempted to work this problem in the past by use of acid brightener and hand polishing of aircraft. A prodigious number of man hours of labor have gone into the F-84G aircraft which this center has utilized for sampling.
>
> The amount of personnel exposure collected in the cloud was roughly proportional to the sample collected on the filter unit. Any exposure which the pilot absorbs on the return flight due to aircraft background is wasted radiation (absorbed by pilot). Because of the large samples currently being required by Los Alamos, and the restrictions placed upon the total dose allowed each pilot, it is necessary to use any and all means of economizing on radiation absorption.

Then he suggested having the sampling B-57 aircraft treated at the factory. But Colonel Houghton's suggestion apparently did not prove feasible, as the decontamination of aircraft continued to be a problem.

The detailed instructions for decontaminating an aircraft revealed to some extent the many attempts to reduce the work involved.

(a) Returning aircraft (air sampling, cloud tracking, and ground survey) taxied by flight crew to the end runway and spotted as directed by designated member of decontamination crew, adjacent to aircraft decontamination area.

(b) Flight crews made their exit according to "SOP" established by personal decontamination personnel.

(c) A rough survey of each incoming aircraft was made to determine extent and degree of contamination. Should the average contamination level be above 20 milliroentgens the aircraft was allowed to "cool" to this level if time allowed.

(d) Prior to decontamination, aircraft was towed to designated washing area. Subject area was selected so as to avoid secondary contamination of other aircraft or personnel.

(e) A detailed exterior survey of aircraft was made prior to application of any decontamination operation. Results were recorded on appropriate forms or sketches and showed beta plus gamma and gamma readings. The same survey was made and recorded for each crew position.

(f) The first washing was made with decontamination trucks using water and detergent ratio of 1 pound the 100 gallons of water.

(g) The monitoring procedures outlined in paragraph e again repeated.

(h) The secondary washing (if required) consisted of a mixture of one part "gunk" and three parts kerosene followed by a water detergent rinse.

(i) The monitoring procedure repeated.

(j) If time permitted and, if advisable, a final washing utilizing water and detergent mixture (1 pound the 100 gallons water) was applied.

The techniques were time-consuming and required great care.

(a) All personnel entering the boundaries of the aircraft decontamination area processed first through the personnel decontamination center and outfitted with hat, gloves, coveralls, and shoes. When departing the aircraft, decontamination area personnel reprocessed through the personnel decontamination center according to their published SOP."

(b) In monitoring, intensity readings were taken at an approximate distance of one inch from the aircraft surface being monitored. Instrument probes were fitted with one inch wire off-sets to aid in standarization of readings. A minimum amount of time devoted to each reading.

(c) During application of the decontamination agent, precautions were taken to avoid spreading of contaminant.

(d) The run off area was monitored and if deemed necessary outlined and marked as a contaminated danger area.

It was anticipated that two crews consisting of five men each would be involved in this phase of the project. Equipment included decontamination trucks, "gunk," kerosene, detergent, and water, tugs and two bars, clothing (hats, gloves, coveralls, and shoes), monitoring instruments, personnel dosimeters, and film badges, and finally, engine repair stands.[8]

In reply to a query from the Naval Radiological Defense Laboratory, Colonel Ernest A. Pinson furnished the effectiveness figures for the process.

> Normal decontamination procedures are 95-98% effective on smooth contaminated surfaces of the aircraft. However, the radiation level in the cockpit or next to the engine is only reduced by a factor of about 10% after the initial high pressure hosing, and about 50% after the first manual scrubbing.
>
> Manpower requirements for the scrubbing process depend on the aircraft type, the degree of decontamination required, and the time available before the aircraft is needed by the

operational organization. Normally decontamination requires approximately sixteen manhours on the F-84 and twenty to twenty-two manhours on the B-57. This does not include manhours for support personnel. Area decontamination rates vary from .009 manhours/sq ft. on the F-84 to .006 manhours/sq ft. on the B-57.

I wish to emphasize that although we are sending this information, as requested, this should not be construed to mean that we approve the decontamination of contaminated aircraft as a part of operational activities. The 4950th Test Group (Nuclear) decontaminates their sampler aircraft primarily for the purpose of avoiding cross contamination during sampling operations.[9]

Then on 21 March 1957, Colonel Kieffer wrote to Mr. K. F. Hertford, Manager of the Albuquerque Operations Office, Atomic Energy Commission, which resulted in additional conferences and communications regarding decontamination policy.[10] "Our experience in nuclear tests in developing knowledge of the psychological effects of radiation on humans, indicates that aircraft decontamination is not required for reasons of personnel safety except in unusual circumstances where radiation intensities are much greater than any we have encountered in our test and sampling aircraft to date. . . We believe it is imperative that we take the lead in establishing a reasonable attitude toward decontamination requirements and therefore desire that our peacetime test requirements for decontamination and rad-safe crew protection be not more elaborate than actually required for personnel safety considerations. Futhermore, substantial economics may result from a reduction in aircraft decontamination efforts." Then he outlined his intentions during Operation PLUMBBOB, which called for a considerably reduced expenditure of manhours in monitoring and decontaminating aircraft. He admitted, "It is possible that as a result of the above procedures some ground crew personnel might exceed the established test limit of 300/mr/week or 3.0 total. We will keep careful records, however, and insure that no individual receives dangerous dosages of radiation and feel confident that by using these new procedures during PLUMBBOB we will accomplish the dual purpose of sponsoring a more realistic attitude toward exposure to radiation within the Air Force and simplifying and economizing test operations."

Immediately following receipt of the above communication, Dr. Plank of Los Alamos conferred with Colonel Kieffer and advised Dr. Graves, in detail, concerning the conversation.[11]

> I found that Kieffer simply could not understand the philosophy which regards every radiation exposure as injurious but accepts minimum exposures for critical jobs. . . I find Kieffer's approach to be extremely discouraging. I would like to recommend that he be informed of the following facts of life:
>
> a. That the aircraft are assigned to support our requirements for bomb cloud sampling and would not otherwise be participating in test operations.
>
> b. That there would appear to be no reason why their use in sampling should be required to support some Air Force objective , particularily when it is clear that the two purposes are not compatible.
>
> c. That the ARC Test Manager supports a philosophy of minimal exposure for critical jobs within limits established by competent scientific authority.
>
> d. That all of the precautions have been found to be necessary for the operational management and accurate technical control of the radiation exposures of the people concerned.
>
> e. That our experience indicates that the discard of any of the precautions is a movement back toward our SANDSTONE experience in which people were injured, and

that this experience covers eight operations in which the sampling mission was accomplished by the USAF in an outstanding manner with no known injuries.

f. That, specifically, routine decontamination of sampling aircraft is required to permit the instrumentation and sample support technicians to work on and in the aircraft, to prevent the build-up of long-lived activity, and increases in the relative background acquired by the airplane on cloud penetration from an otherwise sticky traffic film.

Dr. T. L. Shipman, Health Division Leader for tests, added a few to-the-point remarks on 29 March 1957.[12] "We have always gone on the theory that the only good exposure is zero. . . I could not disagree more violently. Perhaps this means that the Air Force is so superior that exposure which might hurt other people do (sic) not damage them and that rules necessary for other people not apply to Air Force personnel. In any event, I feel that this was a most unfortunate statement. . . I can think of no finer argument to justify the decontamination procedures which have been used in the past. This sentence, in effect, says that we may be able to permit sloppy methods and still squeak by. To this philosophy I take a strong exception." Dr. Shipman concluded, " It is my recommendation that the philosophy expressed in this letter should be firmly rejected as it applies to test operations in Nevada and Eniwetok, and most particularly as it applies to sampling planes. What the Air Force wishes to do at their own bases and in their own tactical operations is, of course, no concern of ours."

An early report, "Radioactivity in the Cloud Produced by an Atomic Bomb Explosion-Operation SANDSTONE," published on 30 June 1948, long served as an aid in preventing injuries to aircraft crews.[13] However, in spite of heavy precautions throughout the tests, some participating personnel experienced general over-exposure during CASTLE following BRAVO Shot. Colonel Karl H. Houghton reported "The fallout was at a dangerous level for at least 140 to 150 miles down wind. . . In addition the naval vessels of the Task Force operated in a fallout of approximately 300 to 400 mr per hour during shot day. Helicopters were handled on the aircraft carrier and small boats were operating as required. Approximately thirty individuals received superficial beta burns as a result of this fallout. The burns were not disabling and did not involve the deep layers of the skin. The gamma exposures ran into several roentgens in most cases."[14]

As no record of over-exposure by sampling personnel has been found, it posed the question: Were protective techniques proper for sampling crews? Although the document was issued prior to the Kieffer-Pinson versus Atomic Energy Commission controversy, Dr. Plank on 23 October 1955, stated clearly that any aircraft crews working for him were going to be given the antiradiation protection he believed necessary.[15] The controversy subsided because extensive sampling experience supported Air Force findings. Nevertheless, the 4926th Test Squadron carried out rigid safety precautions during all operations.[16]

CHAPTER XI

NOTES

1. DF, Ch., Human Factors Div., AFSWC, to DCS/Ops. 7.4, 21 Aug. 1953, subj.: Comments on Briefing, in Hist. Div. files, Sampling.

2. AFSWC TN-56-30, "Evaluation of Some Factors Influencing Radiation Dosage from Penetration of an Atomic Cloud by Manned Aircraft," prep. by Col. Ernest A. Pinson, Capt. Paul M. Crumley, and 1st Lt. William J. Nicholson, Jr., Biophysics Div., Rsch. Dir., June 1956. The reader is referred to the following additional studies conducted by Air Force personnel: P. M. Crumley, J. L. Dick, K. C. Kaericher, and J. W. Nicholson, Jr., Contact Radiation Hazards Associated with Contaminated Aircraft, Operation TEAPOT, Project 2.8a, Wash. 25, D.C.: Armed Forces Special Weapons Project, May 1955; Wright H. Langham, P. M. Crumley, E. A. Pinson, E. C. Anderson, and P. S. Harris, The Radiation Hazards to Personnel Within an Atomic Cloud, Operation UPSHOT/KNOTHOLE, Project 4.1, WT-743, Wash. 25, D.C.: Armed Forces Special Weapons Project, December 1953. The Navy published a report used widely, J. D. Teresi, Radiation Hazards to Aircrews Exposed to the Atomic Cloud of an Atomic Bomb Detonation, San Francisco, Calif., U. S. Naval Radiological Defense Laboratory, 10 December 1952, in Tech. Info. and Intel. Lib.; H. D. Landahl, Calculations of the Hazard Involved in Passage Through a Radioactive Cloud Resulting from a Nominal Atomic Bomb, University of Chicago, USAF Radiation Laboratory, Quarterly Progress Report No. 1, 1951.

3. "Evaluation of Some Factors Influencing Radiation Dosage from Penetration of an Atomic Cloud by Manned Aircraft," 1-2.

4. Ltr., Col. William B. Kieffer, Dep. Cmdr., AFSWC, to K. F. Hertford, Mgr., ALOO, 21 Mar. 1957, n.s., see App.; rpt. "Rad-Safe Experience on Past Tests," (Col. Kieffer), n.d., see App.

5. Ltr., Dr. Harold F. Plank, Asst. Gp. Ldr., J-11, LASL, to Cmdr., 4950th TG (N), 10 Oct. 1956, n.s., in Hist. Div. files, Sampling.

6. Ltr., Col. Kieffer to Hertford, 21 Mar. 1957.

7. DF, Col. Karl H. Houghton, Actg. Dep. CofS for R&D, to DCS/O, AFSWC, 29 July 1954, subj.: Special Services for Sampling Aircraft, in DCS/O files.

8. SOP #SWSS-7-7, Decontamination of Aircraft, prep. by 4950th TG (N), in Hist. Div. files, Sampling.

9. Ltr., Col. Pinson, Ch., Biophysics Div., Rsch. Dir., to CO, USN Rad. Def. Lab., Attn., Mr. Robert J. Crew, 27 Feb. 1957, subj.: Decontamination of Aircraft, see App.

259

10. Ltr., Col. Kieffer to Hertford, 21 Mar. 1957.

11. DF, Plank to Graves, 24 Apr. 1957, subj.: Col. Kieffer's proposal for the Decontamination of Sampling Aircraft, see App.

12. Ltr., T. L. Shipman, MD, Health Div. Leader, LASL, to A. C. Graves, J-Div. Ldr., LASL, 29 Mar. 1957, subj.: Decontamination of Aircraft at Tests, see App.

13. Rpt., "Radioactivity in the Cloud Produced by an Atomic Bomb Explosion, Operation SANDSTONE," prep. by Herbert Scoville, Jr., Lt. Col. J. J. Cody, Jr., USAF, and LCDR E. R. King (MC), USN, TG 7.6 Proj. Rpt., 30 June 1948, pp. 20-21. A report which members of the 4926th Test Squadron (Sampling) relied heavily upon had been published in 1953 by the United States Army. See, "The Penetration of Atomic Clouds by Aircraft," prep. by Maj. Payne S. Harris, (MC), USA, 17 Aug. 1953, see App.

14. Ltr., Col. Karl H. Houghton, Actg. DCS/R&D, to Ch., Human Factors Div., Dir. of Rsch., ARDC, n. d., subj.: Activities Report, see App.

15. DF, Gordon L. Jacks, Cmdr., TU-7, to William F. Ogle, LASL, 23 Oct. 1955, subj.: Dosage Limitations for Aircrews Flying for Hal Plank, see App.

16. Current regulations essentially bear out Dr. Plank's concern, see, SOP #66-61, "Survey and Decontamination of Aircraft," n.d., SOP #66-62, "Aircraft Decontamination," n.d.; and SOP #66-63, "Aircraft and Equipment Decontamination," n.d., all prep. by Capt. Robert J. Booth, 1211th Test Sq. (S), all in Nuclear Applications files, 1211th Test Sq. (S).

CHAPTER XII

SUITABLE SAMPLING AIRCRAFT

With the advent of megaton weapons manned cloud sampling became next to impossible in the upper portion of the clouds. The fundamental problem was one of limited altitude capability.[1] Since the days of Operation RANGER, cloud tracking and manned sampling was an Air Force responsibility.[2] The first such exercise included three B-29 aircraft which carried film and filter sampler containers and results were such that plans moved ahead to include manned aircraft for all samples.[3] And for the early kiloton-yield devices almost any multiengined bomber or jet aircraft fighter reached the necessary altitude and by using planes with various ranges, the Air Force was able to sample a cloud thoroughly.

Early sampling aircraft were the B-29, WB-50, T-33, B-25, and F-84G. They came from Strategic Air Command and were specially fitted. Later the B-47 came into use along with the featherweight B-36.[4] But with the larger devices, none of these aircraft, with the exception of the B-36, had the capability of sampling anything but the stem of the cloud and Los Alamos scientists did not believe that the stem yielded a true indication of the content of the cloud.[5]

Studies of aircraft were initiated to determine characteristics and potential for cloud sampling.[6] But, Major General John S. Mills, Commander, Air Force Special Weapons Center, on 23 December 1953, became impatient with "channels" and wrote to Brigadier General J. Stanley Holtner, Air Force Flight Test Center, "Apparently some misunderstanding is delaying official transmittal of my request to you. Our need for an early fix on the capabilities of the B-57 airplane is generated by Atomic Energy Commission that an aircraft better than the F-84G be modified for collection of samples from within the cloud resulting from each of their nuclear test explosions. By better, they mean primarily the capability of obtaining samples at higher altitudes than is feasible with the F-84G."[7]

From their studies, key men from Air Force Special Weapons Center decided that the B-57 was the outstanding airplane to be used in sampling operations and had set out to get them.[8] But, persuading the Air Force leaders that the need was genuine was an all-agencies task. Dr. Norris E. Bradbury and Dr. Alvin C. Graves of Los Alamos Scientific Laboratory sent strong letters listing their requirements for future tests and mentioned the unsatisfactory samples obtained during previous tests.[9]

On 6 June 1955, Dr. William Ogle, Los Alamos Scientific Laboratory, foresaw unsatisfactory results during REDWING following announcement that the number of B-57 aircraft to be made available was being reduced. ". . . reduction in number of B-57 type aircraft for REDWING sampling is unsatisfactory to this headquarters," he messaged, ". . . It is difficult to understand why USAF is not prepared to supply at this date number and type of aircraft considered by these responsible Air Force agencies as required to satisfy our mission requirements on minimum basis. Reduction particularly surprising. . ." And to insure that possible abetting agencies knew of the reduction, he sent information copies to them.[10]

Admitting that little was yet known about the radioactive cloud, Dr. Duane C. Sewell of the University of California Radiation Laboratory, wrote to Brigadier General Howell M. Estes, Jr., on 17 May 1954, ". . .

I have discussed with several people the problem of radiochemical sampling with guided missiles. I have found that specific information is lacking here on the capabilities of guided missiles." He then listed requirements or objectives he hoped could be met by missiles if they were developed as samplers.[11]

Upon gaining the requested data concerning guided missiles, efforts to obtain suitable manned aircraft continued. The report on the guided missiles as samplers was decidedly unfavorable, although including such units as the Matador, XQ-2 Drone, Snark, and Rascal. Thus, with no possibility of obtaining guided missiles which could do a satisfactory job, officials bent their efforts for the B-57.

At one step of the procurement negotiations, a high-ranking Air Force officer, Colonel Murray A. Bywater, posed the phlegmatic situation that ". . . we could not say that the F-84 was unsatisfactory as a sampling aircraft since this contradicted the stand taken during IVY to obtain F-84 aircraft. . ." with no regard to the progress in aviation represented by the B-57 since their efforts to obtain the F-84 as a sampler or in weapons development. At the same meeting, Joint Task Force SEVEN leaders let it be known that they had not asked for the B-57, giving as a reason, that ". . . this was considered controversial and the paper was designed to eliminate any controversial matter since it might hold up issuance."[12] When Colonel E. M. Gavin objected, a representative replied if the task force decided it needed B-57 aircraft at a later date, that they had sufficient influence to get them. Learning that the Joint Task Force SEVEN had not requested B-57 aircraft required immediate conference with Los Alamos concerning the sampling tanks which Los Alamos Scientific Laboratory was having designed and constructed for the B-57 on the premise that the craft would be available. Task Force officials also indicated that they had not requested a B-52 as had previously been discussed for use in CASTLE.[13] Using all possible "pressure channels," those trying to get B-57 aircraft for sampling resorted to the "power of the press" at least once and tried to attract attention in the Research and Development Quarterly Review. In that article, the arguments for using the B-57 were emphatically stated.[14]

The breakthrough in getting B-57 aircraft was announced on 3 June 1953 at a meeting between Colonel Earl W. Kesling and Dr. Duncan Curry, Los Alamos Scientific Laboratory, during which Colonel Kesling stated that the Air Force Special Weapons Center would receive the first two B-57 aircraft allotted to Air Research and Development Command.[15] General Earle E. Partridge had used his influence, apparently, to get the planes approved and allotted and had informed Major General John S. Mills that it was possible they would be available in time for CASTLE.[16]

Further study of the B-57A persuaded sampling officials that that model's shortcomings were such that the B-57B should be obtained instead. Almost immediately, procurement emphasis was placed on obtaining some "C" in addition to the "A" or the "B" models. Prime improvement in the B-57C was a dual control which enabled new pilot check out with a much higher degree of safety than in earlier models which included only one control. Although other military aircraft were similarly equipped, the degree of proficiency at instrument flying required of sampler pilots made "under-the-hood" training additionally hazardous in the earlier models. The extremely high rate of major accidents suffered with the early B-57 were largely incurred while pilots made transition into the B-57.[17]

Initial effort at obtaining B-57C aircraft was made for two of the models to replace two B-57B aircraft and T-33 aircraft, the latter having been used as trainers for sampling pilots. Argument was advanced that the B-57C aircraft could perform satisfactorily in dual status: For training or as sampler aircraft.[18]

During the discussion, study, and maneuvering for later models, nuclear scientists apparently began to worry that they might be left with no aircraft. But Colonel C. B. Stewart, Vice Commander, Air Force Special Weapons Center, wrote Dr. Graves, assuring him that their efforts would not endanger getting those originally asked for.[19]

Procuring B-57D

Prior to delivery of B-57A aircraft, cloud sampling officials received notice of improvements to be made in the B-57D.[20] According to their information, the B-57D would approach in performance the requirements specified by Los Alamos.[21] Dr. Graves listed specifications in a letter to the Air Force Special Weapons Center on 9 December 1953 and reviewed them in a letter to Major General L. S. Stranathan, Field Command, Armed Forces Special Weapons Project, on 2 August 1954. "Briefly," he wrote, "these characteristics describe a two-place, high-speed aircraft with maximum altitude capability (at least 60,000 feet) and with the ability to carry filter units with a filter capacity high enough to enable the collection of satisfactory cloud samples during an in-cloud flight time of about one hour between H+2 and H+6 hours after burst. I stated in this letter that we required at least six samples on the assumption that each such aircraft would furnish one sample."[22]

He also discussed the eight B-57B aircraft under procurement. It would not operate at an altitude of 60,000 feet, and could only under the most exceptional conditions, and then only for a few minutes, reach 54,000 feet. However, Dr. Grave's letter gave Air Force Special Weapons Center officials a strong argument for B-57D aircraft instead of the "B" models they had been waiting for; here was an airplane which promised satisfactory performance. But getting the B-57D aircraft approved as a cloud sampling aircraft required as much time and as much paperwork and persuasion as the original B-57.

Following the letter to Major General Stranathan, Harold F. Plank of Los Alamos Scientific Laboratory wrote his co-worker, Dr. R. W. Spence, "Since, so far as SWC can now determine, this replacement would involve the procurement of eight additional aircraft at additional expense to the government over the presently planned aircraft inventory, Los Alamos Scientific Laboratory cannot lend its support at this time to any action which the Special Weapons Center may take to plan for the proposed replacement." And he added: ". . . it might be desirable for us to decide at this time to establish a requirement with Special Weapons Center for two or three B-57D aircraft on a loan basis to be used if a large yield weapon test does take place after REDWING, such a requirement would enable Special Weapons Center to explore with Aircraft Allocations the possibility of combining it with a requirement from some other Air Force activity."

Then he encouraged Dr. Spence to take action, ". . . we should personally explore with Al Graves the possibility of submitting the above proposed requirements as soon as possible."[23]

On 13 December 1954, Major Harry H. Elmendorf, after a trip to Wright Air Development Center and Headquarters, Air Research and Development Command, listed findings concerning the performance data of the B-57D and recommended that procurement action be initiated immediately. Time lag after procurement was authorized usually amounted to 18 to 24 months. "This appears to be an ideal aircraft for high altitude sampling and should be procured if sufficient justification can be obtained," he wrote.[24]

Dr. Spence apparently heeded the advice of Dr. Plank, for on 27 January 1955, Dr. Graves wrote to Brigadier General William M. Canterbury, Air Force Special Weapons Center, ". . . I believe that it is timely for me to indicate to you the extent of our need for the altitude capability which is presumably represented by the B-57D aircraft." He then listed the reasons for lending his aid.[25] General Canterbury was apparently quite optimistic about obtaining B-57D aircraft which was reflected in his answer to Dr. Graves on 2 February 1955. In that letter he mentioned that he had a team at Air Force headquarters presenting the need.[26]

The success of the procurement team appeared secured for on 17 February, 1955, a formal request for the B-57D aircraft was submitted.[27] General Canterbury received a notification of the placement of an approval request for three B-57D aircraft on 29 March 1955. "The completeness of the information submitted by your center in justification of this requirement should aid materially in provoking a favorable decision by Headquarters

USAF on allocation of the aircraft," the Chief, Aircraft Allocations Division, Charles W. Early, wrote.[28] Then the Center received additional information concerning the B-57D on 9 June 1955. The letter also informed the Center that the Glenn L. Martin Company was making a study at the direction of Air Force headquarters to determine the possibility of converting the model to a cloud sampler.[29]

The need for personal contact, additional to official authorizations and channels in achieving military tasks was demonstrated in a letter from Dr. Plank to Colonel T. T. Omohundro of the Air Force Special Weapons Center. In the letter, Dr. Plank listed many questions regarding the status of the B-57D, also several rumors he had heard regarding it and stated, "As you know, our contact with Martin no longer exists so that questions with which we may be able to help cannot be answered informally in connection with other matters."[30] After all this paperwork and coordinating and without receiving word of approval for the three B-57D aircraft, Special Weapons Center personnel felt the need for early equipment planning. By July 1955, Center engineers proceeded under the assumption that the B-57D would be available and drew up specifications for special modifications. However, final planning could not be accomplished until Air Force headquarters approved allocation of the aircraft and forwarded expected delivery dates. It appeared these aircraft would not take part in REDWING.[31] Then on 2 November 1955, the Glenn L. Martin Company had finalized its design of the sampling version of the B-57D and Colonel Herschel D. Mahon submitted the drawings and specifications to Los Alamos Scientific Laboratory to insure that all needs would be fulfilled by the craft. He recommended to Dr. Plank that he study the documents and be prepared to discuss the proposed designs with the Glenn L. Martin Company.[32]

In November 1955, Dr. Harold S. Allen of Los Alamos Scientific Laboratory made it plain that his agency had no intention of standing any of the expenses of procuring B-57D samplers, other than that which would be completed when the 32 sampling tanks were delivered. "All funds for this project will have to come from the Air Force," he went on record, and apparently to remove himself from any controversy which might result from the B-57D procurement efforts, indicated that any further correspondence from his agency "should go out over Dr. Bradbury's signature."[33]

There arose then the problem of who was to pay for hanging the tanks onto the B-57D. Los Alamos Scientific Laboratory built the tanks at its own expense. Dr. Plank penned his opinion on an inter-office communication to Dr. Graves and stated that because the B-57D aircraft were being procured by the Air Force solely for sampling and would have very little other possible employment, the Air Force should pay for the installation. "I do not believe that we would deny ourselves the capability of the B-57D airplane for the sake of the cost of hanging our filter units on it, but it seems justified to ask USAF to pay for this because for the first time the B-57D sampling airplane will represent an instrument uniquely adapted to sampling purposes and not readily convertible to some other USAF mission." He then indicated that Los Alamos may be losing interest in high-altitude sampling, by stating that "such a letter should carefully avoid implying a lack of interest on our part or that we no longer consider the collection of very high altitude samples to be important (if in fact we still think it is)."[34]

From such a November attitude, Dr. Plank had apparently jelled his opinion concerning the need for the laboratory to get behind the procurement of the B-57D. On 12 December 1955, he urged Dr. Graves to take whatever steps necessary to assist the Air Force Special Weapons Center. Dr. Plank had apparently been informally notified that Headquarters, United States Air Force, rejected the two-year-old request for B-57D as sampling aircraft. In a note to Dr. Graves, he expressed apprehension regarding their sampling program and repeated the reasons for acquiring B-57D aircraft.[35]

To supply General Canterbury with all possible aid in obtaining the B-57D aircraft, Major Harry H. Elmendorf provided a detailed discussion of "AFSWC Sampling Capability" which was a strong argument for the later models.[36]

As wording used in a letter written by Dr. Bradbury to General Canterbury was almost verbatim of that used in the urgent letter to Dr. Graves, it could be assumed that he had acted upon Dr. Plank's note immediately. At any rate, Dr. Bradbury threw the entire weight of the Los Alamos Scientific Laboratory behind the B-57D aircraft, with the exception of any promise of financial aid.[37] A month later, General Canterbury replied that the procurement wheels had started turning for General Thomas S. Power, Commander, Air Research and Development Command, had urged him to renew efforts to get B-57D aircraft. He also assured Dr. Bradbury that Los Alamos Scientific

Laboratory would not be required to stand any of the cost of procurement or modification.[38]

Headquarters, Task Group 7.4, Provisional, assumed that the model would be available for use during PILGRIM. "Completely modified B-57D aircraft should be assigned to the organization for a minimum of four months before departure date for the Pacific Proving Ground," and officials listed the reasons for the four-month requirement. Colonel John S. Samuel, Commander, apparently did not know that the plane was not yet approved for use as a sampler.[39]

Additional arguments in favor of the B-57D came with the CHEROKEE Shot of Operation REDWING. During the shot, which was made at 5,000 feet altitude, the B-57B aircraft chalked up a near failure in obtaining samples. "The yield of the weapon is, therefore, known with less accuracy than might be desired," Dr Graves wrote to General Canterbury. "As a matter of direct observation," he continued, "very satisfactory samples probably could have been collected in a layer of bomb cloud which persisted at a 2,000 to 5,000 foot higher altitude than could be attained by the B-57B type airplane."* [40]

Using every opportunity to drive home the need for the B-57D, Colonel Thomas R. Waddleton of Headquarters, Air Research and Development Command, wrote to the Deputy Chief of Staff, Development, Air Force headquarters, "Their requirements still exist, and can most economically and efficiently be met by B-57D aircraft. . . the requirements for the assignment of B-57D aircraft for AFSWC sampling is reaffirmed. Request priority action by

*The B-57D promised capabilities of as much as 8,000 feet additional altitude over that attainable by the B-57B.

your headquarters in the allocation of these aircraft."[41]

First hint that the B-57D would be made available at a certain specified time appeared in an indorsement to the Commander, 4950th Test Group (Nuclear), dated 27 September 1956. Forecast was for arrival of the craft during early fall 1957.[42]

A hint of planning for insufficient numbers of B-57 was dropped on 14 December 1956. Colonel A. W. Carney, Deputy Chief of Staff, Operations, for the Air Force Special Weapons Center, on that date appealed to Mr. James E. Reeves, Director Test Division, Atomic Energy Commission, for the planned testing program, stating that it was the Center commander's concern that his unit would be unable to perform the sampling required by the Atomic Energy Commission.[43] Colonel Carney made an up-to-date repeat of the review to obtain action on the B-57D requests late in 1956. "It is also to advise you that unless decisive action can be taken to provide a minimum of three (3) RB-57D-2 aircraft to AFSWC by not later than 1 November 1957, the Atomic Energy Commission requirements for HARDTACK cannot be fulfilled." In his summary, Colonel Carney sent copies of 11 documents as well as 8 separately discussed arguments for early approval and delivery of the B-57D.[44]

Without making any direct request for B-57D aircraft the University of California Radiation Laboratory got into the act by defining requirements for future cloud samplers. On 18 December 1956, that agency, represented by Dr. Roger E. Batzel, Assistant Chemistry Division Leader, wrote to Dr. Gaelen Felt, Commander, 7.1, Los Alamos Scientific Laboratory, through Rear Admiral Byron H. Hanlon, Commander, Joint Task Force SEVEN, that only the B-57D could qualify as the required sampling aircraft.[45]

Meanwhile all agencies continued their efforts in the work of insuring that B-57D aircraft were approved and furnished with suitable modifications and sampling equipment. Dr. Plank wrote Lieutenant Colonel Richard J. Hynes, Director of Operations for the 4950th Test Group (Nuclear) on 24 January 1957, and he sent another to Dr. Graves on 25 January 1957, and Dr. Graves to K. F. Hertford, 5 March 1957.[46] Admiral Hanlon assured Dr. Felt that he fully agreed to the collusion between all agencies to insure getting the B-57D. "I've instructed my staff to assist in this procurement in any way that the operational requirements of HARDTACK will support," he wrote.[47]

Slightly more than four years after lending his first written support to the B-57 procurement campaign, Dr. Graves repeated the requirements to Brigadier General Canterbury. He further enlarged the requirements to include ten B-47B and four B-57B aircraft. He also sent notice of his intentions to use his influence with the Division of Military Applications to obtain that agency's assistance in getting the planes.[48]

Once fairly sure that their joint needs would be met on time by delivery of the B-57D, that confidence was jarred solidly as shown by a note of 26 February 1957. Colonel Carney exhibited extreme concern resulting from the receipt of information that the B-57D would not be available prior to 1960, or not in time for use during HARDTACK.[49] A "piggyback" sampling installation on a B-57D owned by Strategic Air Command was considered and a board convened to investigate that angle. The U-2 aircraft was suggested as a possibility, but the note expressed doubt as to its utility or availability because of the secrecy which surrounded the development of the ultra-high altitude, long-range aircraft. The wave of discouragement which caused Colonel Carney to make his appeal for action apparently struck another high Air Force official, simultaneously, for on the same date Colonel William A. Hunter wrote to the Commander, 4950th Test Group, "Assignment of additional B-57B/C or RB-57D aircraft was extremely doubtful until at least 1960,. . . It is, therefore, recommended that you plan to again use the F-84G, B-57B, but at the same time consider that other B-57 aircraft might become available in time to be used." [50] On the following day, Colonel Carney dispatched a message to Air Research and Development Command seeking information concerning capabilities, availability, and other data on the U-2.[51]

Not until March 1957 did any hope arrive. Returning from a hurried trip to Headquarters, Air Materiel Command, and to the Glenn L. Martin Air Company's factory, Colonel Hunter, Major Malcolm S. Bounds, Major Charles S. Oldfield and First Lieutenant Robert L. Kelley reported on several concessions and agreements obtained. The quartet learned that Air Materiel Command officials were willing to hasten procurement and modifications. It was learned at the Glenn L. Martin plant, that the need for a two-place version had been eliminated because of perfection of the auto pilot which eliminated the need for removing Strategic Air Command equipment so that the "turn-around-time" of a B-57 borrowed from the

Strategic Air Command "would be a matter of hours."

Because the first six RB-57D aircraft to come off of the production line were not to include in-flight refueling equipment, it was deemed logical to get those first six planes for modification to samplers. All other findings were favorable to the hopes of having them in time for employment during HARDTACK. Meanwhile, the requirements had been upped to a total of 16 B-57 airplanes, six of which were to be RB-57D.[52] A short and cryptic message of 19 August 1957, apparently signaled the end of the four years of personal and paper persuasion. Information received from Commander of Joint Task Force SEVEN indicated that modification of B-57D aircraft by Glenn L. Martin Company would proceed as originally planned.[53]

The victory was short lived, for when HARDTACK tests requiring 60,000 foot sampling came off, the 4080th Strategic Reconnaissance Wing (Light), Strategic Air Command, was called upon to accomplish sampling. After years of negotiations, the unit responsible for, and highly competent at nuclear cloud sampling, found itself, as military units often do, standing on the sidelines watching a "line" outfit accomplish the mission. According to Captain Cale Herry in June 1961, the 4926th Test Squadron (Sampling) never received a B-57D aircraft.[54]

CHAPTER XII

NOTES

1. Ltr., Brig. Gen. William M. Canterbury, Cmdr., AFSWC, to Brig. Gen. Daniel E. Hooks, AFOAT-1, n. d. (1955), subj.: B-57D Aircraft for Sampling, see App.

2. Rpt., "Interim Report on the Sampling of Atomic Clouds with Manned Aircraft," prep. by personnel of AFSWC, (Summer of 1951), see App.

3. Memo. to Col. W. B. Reed, AFOAT-1, prep. by J. J. Cody, Jr., Ch., Spec. Projs. Br., AFOAT-1, 12 Feb. 1951, subj.: Preliminary Report on AFOAT-1 Participation in Operation RANGER; interview with Col. Paul H. Fackler, AFOAT-1, conducted by Warren E. Greene, AFSWC Historian, 24 July 1957, see App.

4. Interview with Dr. Harold F. Plank, J-11 Leader, LASL, conducted by Greene, 28 Aug. 1957; memo. for General Canterbury, prep. by Col. Karl H. Houghton, Human Factors, Rsch. Dir., AFSWC, 6 Jan. 1956, subj.: Cloud Sampling, see App., passim.

5. Ibid.

6. For an extensive compilation of studies regarding decontamination of test aircraft for cloud sampling see AFSWC Hist. Div. files, Sampling. Included are reports prepared by the 4926th Test Sq. (S), LASL, UCRL, 4950th TG (N), and DCS/O, AFSWC.

7. Ltr., Maj. Gen. John S. Mills, Cmdr., AFSWC, to Brig. Gen. J. Stanley Holtner, Cmdr., AFFTC, 23 Dec. 1953, subj.: B-57 Aircraft for Sampling, see App.

8. All interested organizations favored the B-57 as the most promising sampler aircraft, see reports and studies in Hist. Div. files, Sampling.

9. Ltr., Maj. Gen. Mills, to CG, ARDC, 27 Feb. 1953, subj.: Request for Assignment of Aircraft to Air Force Special Weapons Center for Overseas Tests, and 1st Ind., Col. John W. Carpenter III, CofS, ARDC, 29 Mar. 1953, see App.

10. TWX, JO 103, CTG 7.1, LASL, to CJTF Admin., Wash., D. C., 6 June 1955, see App.

11. Ltr., Duane C. Sewell, UCRL, to Brig. Gen. Howell M. Estes, Jr., Cmdr., TG 7.4, 17 May 1954, subj.: Sampling with Guided Missiles, see App.

12. Ltr., Brig. Gen. Estes to Sewell, 9 June 1954, subj.: Sampling with Guided Missiles; ltr., Col. E. M. Gavin, Dep. Cmdr., for O/S Tests, AFSWC, 26 Feb. 1953, subj.: Staff Visit Report to Headquarters Joint

Task Force SEVEN and Glenn L. Martin Company, see App.

13. Ibid.

14. "The B-57B as a Sampler Aircraft," R&D Quarterly Review, 30 June 1955, 84-85, see App.

15. Memo. to Staff, prep. by Duncan Curry, Jr., LASL, 3 June 1953, subj.: Meeting with Col. Kesling, Dep. Cmdr., TG 7.4; memo. to TG-7, prep. by W. E. Ogle, LASL, 14 July 1953, subj.: High Altitude Sampling Aircraft, see App.

16. TWX TUS580, Off. of the Test Dir., Nev. Test Site, to LASL, 3 May 1955, see App.

17. For a more complete discussion of shortcomings, problems encountered and operational difficulties in using B-57A aircraft, see compilation of studies in AFSWC Hist. Div. files, Sampling.

18. Copies of correspondence for the purpose of obtaining B-57C or B-57D aircraft to replace B-57A models are found in AFSWC Hist. Div. files, Sampling.

19. Ltr., Col. C. B. Stewart, Vice Cmdr., AFSWC, to Dr. A. C. Graves, J-Div. Leader, LASL, 3 Mar. 1955, n.s., see App.

20. Ltr., Brig. Gen. Canterbury to Brig. Gen. Hooks, n.d., n. subj.

21. Ltr., Brig. Gen. Estes to Brig. Gen. Canterbury, 27 Oct. 1954, n. subj., see App.

22. Ltr., Dr. Graves to Maj. Gen. L. S. Stranathan, CG, FC/AFSWP, 2 Aug. 1954, subj.: Requirements for Aircraft Sampling Equipment, see App.

23. Ltr., Dr. Plank to Dr. R. W. Spence, LASL, 30 Nov. 1954, subj.: Possible Requirement of B-57D Airplanes for Special High Altitude Sampling on Operations after REDWING, see App.

24. DF, Maj. Harry H. Elmendorf, Proj. Off., Ops. Plans Br., AFSWC, to Ch., Test-Ops. Div., 13 Dec. 1954, subj.: Trip Report to WADC and Hq., ARDC, see App.

25. Ltr., Dr. Graves to Brig. Gen. Canterbury, 27 Jan. 1955, subj.: B-57D Aircraft, see App.

26. Ltr., Brig. Gen. Canterbury to Dr. Graves, 2 Feb. 1955, subj.: B-57D Aircraft, see App.

27. Ltr., Col. Herschel D. Mahon, DCS/O, AFSWC, to Cmdr., ARDC, 17 Feb. 1955, subj.: Request for Sampling Aircraft, see App.

28. Ltr., Charles W. Earley, Ch., Acft. Allocations Div., AMC, to Cmdr., AFSWC, 29 Mar. 1955, subj.: Request for B-57D Aircraft, see App.

29. Ltr., Maj. Richard P. Gingland, Asst. Ch., B-57 WSPO, to Cmdr., AFSWC, Attn.: SWOPT, Col. T. T. Omohundro, 9 June 1955, subj.: RB-57D Aircraft Cloud Sampling Capabilities, see App.

30. Ltr., Dr. Plank to Cmdr., AFSWC, Attn.: Col. Omohundro, 21 June 1955, subj.: B-57D Aircraft, see App.

31. Prog. Plan 4-55, "Equipping RB-57D Aircraft for Sampling," prep. by Col. Charles B. Stewart, Dep. Cmdr., AFSWC, 18 July 1955, see App.

32. Ltr., Col. Mahon to LASL, Attn.: Dr. Plank, 2 Nov. 1955, subj.: Proposal for Air Sampling Version of RB-57D(C).

33. Ltr., Harry H. Allen, Dept. Head, LASL, to Dir's Off., Dept. of Sup. and Property, 18 Nov. 1955, subj.: RB-57D Sampling Version, see App.

34. Ltr., Dr. Plank to Dr. Graves, 12 Dec. 1955, subj.: Very High Altitude Sampler, see App.

35. Ltr., Dr. Plank to Dr. Graves, 12 Dec. 1955, subj.: Very High Altitude Sampler, see App.

36. Memo. for Maj. Gen. Canterbury, prep. by H. H. Elmendorf, Proj. Off., Ops. Plans Br., AFSWC, 13 Jan. 1956, subj.: AFSWC Sampling Capability, see App.

37. Ltr., Dr. Norris E. Bradbury, Dir., LASL, to Brig. Gen. Canterbury, 23 Dec. 1955, n.s., see App.

38. Ltr., Brig. Gen. Canterbury to Dr. Bradbury, 23 Feb. 1956, n.s., see App.

39. Ltr., Col. John S. Samuel, Cmdr., TG 7.4 (P), to Cmdr., AFSWC, Attn.: DCS/O, Col. Mahon, 20 Apr. 1956, subj.: Requirement for Sampler Aircraft, see App.

40. Ltr., Dr. Graves to Brig. Gen. Canterbury, 2 July 1956, n.s., see App.

41. 3rd Ind. (Ltr., SWOTR, AFSWC, to Cmdr., ARDC, 27 Apr. 1956, subj.: (C) Schedule Justification for B-57D Sampler), Lt. Col. Thomas R. Waddleton, Asst. Ch., Test Ops. Div., ARDC, to Dep. CofS, Dev., USAF, 14 Aug. 1956, see App.

42. 1st Ind. (ltr., RDTAB, ARDC, to Cmdr., AFSWC, 20 Sep. 1956, subj.: RB-57D Aircraft for AFSWC), Col. Hunter to Cmdr., 4950th TG (N), 27 Sep. 1956, see App.

43. Ltr., Col. A. W. Carney, DCS/O, AFSWC, to James E. Reeves, Dir. Test Div., ALOO, 14 Dec. 1956, subj.: Cloud Sampling Requirements.

44. Ltr., Col. Carney to Cmdr., ARDC,15 Nov. 1956, subj.: Review of Action Taken to Obtain RB-57D Sampling Aircraft, see App.

45. Ltr., Dr. Roger E. Batzel, Asst. Chem. Div. Leader, UCRL, to RAdm. Byron H. Hanlon, Cmdr., JTF SEVEN, 18 Dec. 1956, subj.: Sampling Requirements for Operation HARDTACK, see App.

46. For further correspondence concerning future cloud sampling requirements, see AFSWC Hist. Div. files, Sampling, letters of Drs. Plank and Graves.

47. Ltr., RAdm. B. H. Hanlon, Cmdr., JTF-7, to Dr. Gaelen L. Felt, Cmdr., TG 7.1, 28 Jan. 1957, n.s.

48. Ltr., Dr. Graves to Brig. Gen. Canterbury, 30 Jan. 1957, n.s., see App.

49. DF, Col. Carney to Carrier Div., Bomb. Br., Dev. Dir., 26 Feb. 1957, subj.: Sampling Equipment, see App.

50. Ltr., Col. Hunter, to Cmdr., 4950th TG (N), 26 Feb. 1957, subj.: Future Sampling Operations, see App.

51. TWX, SWOTR-2-8-M, Cmdr., AFSWC, to Cmdr., ARDC, 8 Feb. 1957.

52. Trip Rpt., prep. by Col. Hunter, AFSWC, et al.,21 Mar. 1957, subj.: Possible Modification of Ten Aircraft to a Sampler Configuration Prior to 1 January 1958, see App.

53. TWX, SWG-8-5-E, LASL to William Ogle, Test Gp., Mercury, Nev., 19 Aug. 1957, see App.

54. Interview with Capt. Cale Herry, Pilot, 4926th Test Sq., (S), 14 June 1961, conducted by MSgt. Leland B. Taylor, Hist. Div., AFSWC.

CHAPTER XIII

THE 4926TH TEST SQUADRON (SAMPLING)

Early proposals for a permanent atomic cloud sampling unit came almost as soon as sampling by manned aircraft proved feasible. Following the first penetrations of an atomic cloud, Colonel Joseph J. Cody, AFOAT-1, reported to his organization that manned sampling aircraft could be used for future nuclear tests and suggested that ". . . a test unit be formed to do this type of operation."[1] Colonel Fackler returning to his duties with Air Weather Service, drew up a proposal for such an organization in mid-1951, and it called for C-82 transport aircraft, helicopters, radio jeeps, B-29 sampling aircraft, cloud trackers, survey aircraft, and other support aircraft to be combined into a permanent outfit. Colonel Fackler coordinated the plan with favorable response, however, funds and manpower were limited and the Korean war absorbed Air Force considerations.*

The 4926th Test Squadron (Sampling) was brought into being largely through the vision of Colonel Fackler. On 1 August 1951, he transferred to Kirtland, and became an air controller for Operation BUSTER/JANGLE in October 1951. During the series, he outlined a plan for a permanent unit to General John S. Mills, then commanding the Special Weapons Command.

Following Operation BUSTER/JANGLE, General Mills considered the proposed test unit further but thought the plan too elaborate for the Air Force at that time. However, he asked for a detailed organizational plan incorporating the command's cloud sampling responsibilities. Colonel

*Had Colonel Fackler's planned organization been established, it would have performed the duties which were assigned to the newly established 4950th Test Group (Nuclear), some five years later.

THRU THESE PORTALS PASS THE

OMNIS IP TIGRIS

BEST DAMN CREWS IN THE WORLD

4926th TEST SQUADRON (SAMPLING)

OPERATIONS

SWEH-2-0034

281

Fackler started with a basic jet fighter squadron organization. He retained the operational personnel and the aircraft portions of the standard squadron, then added a rad-safe, later called the nuclear applications section.

The Air Force Special Weapons Center approved the plan for a sampling squadron and, late in 1952, a number of meetings were held to work out a formal proposal for the Air Research and Development Command.*[2] A special staff, meeting at the Center, completed a study by 12 December 1952,[3] and on 15 December staff officials determined to include supporting documents for additional emphasis. They drew up a proposed table of distribution, a tentative time-phasing, and a study of future aircraft requirements.[4] Colonel Daniel E. Hooks, Chief of Staff, forwarded the proposal to the Air Research and Development Command on 21 January 1953.[5]

The proposal opened with a statement by Dr. Alvin C. Graves, Test Director of the Los Alamos Scientific Laboratory, to the effect that cloud samples were the primary method of determining yield and efficiency of a nuclear blast and were extremely important. The Special Weapons Center assumed that at least two atomic test series would be fired each year; either two continental tests, or a continental test and overseas test. For Operation BUSTER/JANGLE and TUMBLER/SNAPPER, the sampling pilots had been active for approximately four months. This indicated that pilots of

*On 1 April 1952, about the time Colonel Fackler was working up his plan for General Mills, the Special Weapons Command was abolished and became the Air Force Special Weapons Center under the Air Research and Development Command.

a permanent sampling squadron would be actively engaged about eight months of the year when two continental test series were fired, and probably more than eight months when one of the two series was overseas.

There were two methods of obtaining sampler pilots, the report cited. For overseas tests, pilots and equipment were lent by some operational organization and subsequently trained in cloud sampling techniques. Until experienced, the pilots usually returned with poor samples. Training new pilots for each overseas test series was necessary since pilots seldom participated in more than one operation. For continental tests, the 4925th Test Group (Atomic) conducted current sampling. Pilots served on temporary basis, were trained, carried out the mission, then released to their parent organization. Both methods were wasteful, because the pilot training program had to be repeated each time.

The Center proposed:

> . . . a permanent capability to be developed within the Special Weapons Center for cloud sampling activities. This capability should be assigned to the 4925th Test Group (Atomic) along with permanently assigned aircraft, pilots and supporting personnel and equipment to permit the unit to function on a permanent operating basis.

The report indicated that placing the unit in the 4925th would give it flexibility, because pilots could be exchanged between sampling and other units within the group. Another advantage would be the added ability to support small, one shot tests. Dr. Graves had indicated the Los Alamos Scientific Laboratory would like to be able to schedule and fire single nuclear shots in Nevada with approximately one month's preparation. A permanent sampling unit would retain personnel with technical skills needed, which would improve the samples collected and make introduction of new equipment easier. Under the dosage and sample size criteria then in effect, the Center reported that ". . . pilots can participate in four or five shots per operation at a rate approximately two a year for an indefinite period." Such a sampling unit required about nine F-84-type aircraft especially modified, the Center believed, with additional aircraft in "flying storage" to meet overseas sampling requirements.[6]

Colonel Hooks requested that a sampling test squadron be authorized, having a strength of 24 officers and 121 airmen. Most of the personnel spaces could be supplied from authorizations for Operation IVY's Task Group 132.4. The F-84G aircraft were already assigned to the Center.[7]

Although the proposal for a permanent sampling squadron was an Air Force product, Colonel Karl H. Houghton, Colonel Fackler, and Dr. Plank put their heads together to get support from the Atomic Energy Commission.[8] On 9 February 1953, Chairman Gordon Dean of the Atomic Energy Commission wrote Robert LeBaron, head of the Military Liaison Committee, concerning the proposal. Because of the increased complexity of sampling and the importance of samples in testing, he ". . . strongly recommended that a permanent cloud sampling unit be established." Such a unit would make available at all times experienced cloud sampling personnel to be used on tests conducted on short notice. It would reduce the hazard inherent in using inexperienced pilots, save the cost of modifying new aircraft for each operation, and relieve the impact of unscheduled demands for sampler pilots and aircraft during over-all Air Force planning. It appeared that testing was to be continued, he wrote, with at least two test series each year. Pretest planning and practice and post-test development work would keep the unit occupied on a continuous, full-time basis.[9]

Air Force headquarters approved the sampling unit and, on 27 February 1953, the Air Research and Development Command issued General Order Number 25, establishing the 4926th Test Squadron (Sampling) and assigning it to the 4925th Test Group (Atomic).[10] The squadron was to be organized on 1 April 1953.[11] The order called for 24 officers and 121 airmen.[12]

On 1 April 1953, Major Hebert W. McQuown, Assistant Chief of the Materiel Division, 4925th Test Group (Atomic), took on the added duty of squadron commander. During April, May, and June 1953, while the Center engaged in support of Operation UPSHOT/KNOTHOLE, the growth of the 4926th was slow. Major McQuown worked to secure men for the squadron's staff and in preparing a training program to be conducted following the test. The major planned to organize and man the squadron between June and September 1953, while the sampler aircraft were undergoing wiring modifications. Then, from October 1953 to about January 1954, the new squadron would undergo an intensive training program.[13]

By the middle of May 1953, there were nine officers with Major McQuown commanding. Captain Claiborne F. Bickham was the Aircraft Maintenance Officer. In the Operations Branch, Pilot Training Program, were Captain Malcolm S. Bounds, Captain Quentin C. Ellingson, Captain Saul Faktorow, Captain Francis B. Meinke, First Lieutenant Lewis W. Bruce, First Lieutenant Sam D. McGehee, and First Lieutenant John M. Rowan.

As Operation UPSHOT/KNOTHOLE came to an end, the 4926th took on a permanent look. Major McQuown returned to his duties with the 4925th Test Group (Atomic). Lieutenant Colonel James A. Watkins, chief of Flight Operations Branch of the 4925th, became the first permanent commander. Lieutenant Colonel Watkins was a leading ace of the Pacific theater during World War II, having destroyed 12 Japanese aircraft and flown 135 combat missions. Major James T. Corn became operations officer, Major Finis Mitchell was munitions officer of the nuclear applications section. Captain Claiborne F. Bickham served as aircraft maintenance officer. So that in the middle of June 1953, the squadron had 17 officers assigned.[15]

The Test Aircraft Unit (TAU)

Beginning with Operation CASTLE, conducted in the Eniwetok Proving Ground in 1954, and for all subsequent test operations, the 4926th Test Squadron provided organizational framework for the Test Aircraft Unit. The unit came into being only in preparation for and during a test series to provide command operational control over all elements in the operations area. The organizational structure reflected the unique mission of the 4926th Test Squadron. In addition to executing the normal functional sections of the mission squadron, which at the time of Operation CASTLE had two different types of mission aircraft, the 4926th maintained a nuclear applications section with a primary function to instrument and prepare aircraft for nuclear cloud sampling. This section also removed the cloud samples from the aircraft and prepared them for shipment to appropriate laboratories for analyses. In addition, the Nuclear Applications Section operated aircraft decontamination and personal dosimetry facilities. The squadron operated independently on temporary duty for extended periods of time, to provide the personnel to fill out the Test Aircraft Unit, and furnish limited support to the austerely manned elements participating in nuclear test operations. These extended periods of temporary duty made it imperative that the squadron operated independently of any consolidated base function, particularly that of maintenance.

Under the command of Colonel A. Ousley during Operation REDWING, the 4926th Test Squadron (Sampling) was fully operational and worked closely with eight separate operational elements. The Sampling Decontamination Element conducted nuclear cloud sampling operations with ten F-84G and six B-57B aircraft. These aircraft met the sampling requirements of nuclear clouds which consisted of five samples per detonation ranging in altitudes up to 55,000 feet. They procured samples through use of exposed filter papers during flight through the nuclear clouds or in gas bottles filled under similar conditions. Its members removed bottles or filter papers through specific techniques and stored and shipped these samples to the Atomic Energy Commission in the States. It also functioned as an administrative group headquarters for the Test Aircraft Unit.

The Indirect Bomb Damage Assessment Element, a detachment of the 301st Bombardment Wing, Strategic Air Command, Barksdale Air Force Base, Louisiana, evaluated current operational procedures, techniques, and equipment used in accomplishing the data phase of indirect bomb damage assessment of nuclear weapons. To accomplish this mission, 3 B-47 aircraft, 3 combat crews, and 36 support personnel participated in REDWING. Each aircraft had cameras to photograph bomb burst and fireball, with instruments to determine yield, and with equipment to determine precise aircraft speed and range.

The Wright Air Development Center Weapons Effect Element used seven aircraft in pursuing its mission: a B-47E, an RB-52B, a B-66B, a B-57B, an F-101A, and two F-84F. One of the two F-84F aircraft was a capabilities aircraft; the other was a side loads effect aircraft.

The Early Penetration Element utilized pilots and B-57B aircraft from the 345th Bombardment Group and the 405th Bombardment Group, Langley Air Force Base, Virginia, and from the 461st Bombardment Group, Blytheville Air Force Base, Arkansas. These groups belonged to the Tactical Air Command. Their mission was the securing of information by early penetration of nuclear clouds at high altitudes.

The Navy Effects Element used an A3C and a P2V aircraft furnished by the Naval Air Special Weapons Facility, Kirtland Air Force Base, and basically concerned itself with the determination of response of aircraft structures to thermonuclear explosions.

The Ionospheric Element, a detachment from the Air Force Cambridge Research Center, consisted of 21 personnel and a specially instrumented JC-97 aircraft. The plane had the only airborne ionospheric recorder in existence at that time. The unit was designed to probe and determine limits, character, and magnitude of ionospheric changes resulting from nuclear detonations.

The Drop and Canister Element, provided by the 4928th Test Squadron of the 4925th Test Group (Atomic), consisted of two B-52 and one B-36 aircraft for drops. The B-52 aircraft, for example, were concerned with dropping the CHEROKEE device, one B-52 maintained for use as a back-up aircraft. The B-36, after dropping the canisters during the CHEROKEE test, was used to drop the OSAGE weapon.

The eighth group of the Test Aircraft Unit was the AFOAT-1 Element, manned, trained, and equipped by the Office of the Assistant for Atomic Energy, utilizing aircraft of the Sampling and Decontamination Element.

In general, the activities of the 4926th were recorded within the histories of each of the major nuclear tests included in this work. However, the daily activities of the squadron, its minor accomplishments, personalities, and problems revealed a story which was all too often missing from Air Force organizations. The story of the 4926th was one of cohesion, cooperation, enthusiasm, and leadership, of pride of accomplishment, of all members working together with a common goal. Proving that the age-old principles of leadership still work were the records which contained "no AWOLS," "No Courts Martial," "No Article 15s," or other incidents associated with the records of all too many Air Force units. Such continuity of command responsibility was much more difficult to achieve with the squadron for the simple reason that immediately any member absorbed his limit of radiation, or expended his quota of temporary duty, he transferred.[16]

The difficulties of maintaining a sufficient force of sampling pilots, radiac technicians, aircraft maintenance specialists, and others associated with sampling were well exemplified during Operation HARDTACK. Staffed with a force planned to be adequate for 24 shots, to take place within a 90-day period, the 4926th Test Squadron (Sampling) found itself saddled with 34 shots extending over a much longer period.

"As a result, all sampling element personnel stand to accrue additional radiation dosage. The sources of this dosage will be the extra sampling missions flown (for the aircrews) and the extra handling of radioactive aircraft and sample collection equipment (for ground crews). There may also be a certain amount of radiation from fallout. This can easily amount to 1r or more if the first three months of the operation can be used as a guide," recorded the Final Report. ". . . There are many personnel in the sampling element that are rapidly approaching their MPE (Maximum Permissable Exposure) and will almost certainly exceed it during the remainder of the operation unless specific measures are taken. In all of the cases where the MPE has been exceeded, the cause can be attributed to one of several unforseen factors. These factors are: many events only one day apart, a moderate increase in the particulate sampling requirements, a very large increase in the gaseous sampling requirements, a shortage of sampling equipment, especially gaseous sampling, and a shortage of personnel to handle the sampling equipment."[17]

The report then provided a detailed discussion of the problems, what action had been taken to prevent overdosage, a list of recommendations for action to be taken by higher echelons. From the large number of documents, staff studies, and plans concerned with future tests, all of which referred to the need for an economy accruing from a permanent sampling unit, it was evident that attempts to disband the 4926th cropped up fairly regularly. Almost immediately after the unit was fully manned, such a document appeared but was never used.[18]

The squadron was often called "a TDY outfit." Early realizing that the major portion of their operations would be elsewhere than at home base (Kirtland), unit leaders evolved a "two-base concept" for the unit. Under this mode of operation, all periodic inspections and controlled major maintenance was done at Kirtland. To accomplish those maintenance requirements, one officer and 40 airmen were usually retained there, with, during Operation PLUMBBOB as an example, 26 officers and 130 airmen on duty with the forward element. During PLUMBBOB, the squadron flew a total of 1821 sorties, maintained an "in-commission rate" of 88 per cent and an "aircraft out of commission for parts" rate of less than one per cent. While operating under the two-base concept, the squadron won the Air Force Special Weapons Center quarterly flying safety award and was runner up for the second quarter award.[19]

In addition to their primary duties, squadron personnel had the additional job of training National Guard pilots and airmen for sampling operations. Indoctrination and training were also given Royal Canadian Air Force crews, Strategic Air Command crews, and other Air Force pilots in sampling techniques. Squadron members gave training in personnel dosimetry and precautionary measures to individuals of the 4935th Air Base Squadron and the Test Aircraft Unit.

Among the special achievements already cited, the squadron received an accolade for its efficient conduct in support of Project ROVER. "Air samples were successfully collected on Experimental Plan No. 16," Mr. Paul R. Guthals of the Los Alamos Scientific Laboratory wrote, "of KIWI-A at the Nevada Test Site recently. This was largely a result of the close cordial working relationship which prevailed between the Project Officer and the scientific people associated with the program. Another important factor which led to the very satisfactory accomplishment of the mission was the 'can do' attitude of all the members of the 4926th Test Squadron."[20]

The test squadron supported the United States Weather Bureau's efforts, in 1960, to determine the mechanism by which air is exchanged between the stratosphere and the troposphere. Using radioactive debris as the tracer material, the squadron collected particulate samples at altitudes and areas specified by the Weather Bureau. "Without the helpful and enthusiastic spirit displayed by these organizations and the efficient and workmanlike performance of their missions, the sampling program could not have been accomplished," officials of the Weather Bureau commented at the conclusion of the mission.[21]

Early in its history, the squadron was authorized direct communication with officials of the Los Alamos Scientific Laboratory.[22] Throughout this relationship, members of both groups developed feelings of mutual respect and cooperation. A recent squadron history reported:[23]

Some seventeen of the officer personnel made a field trip to the Los Alamos Scientific Laboratory and received a tour of the facilities, as well as a comprehensive briefing on the projects and the future sampling requirements of the Laboratory. We followed a myriad of steps in processing the information derived from the samples collected by the 4926th Test Squadron (Sampling). To a man, those in attendance felt that the trip was extremely interesting and worthwhile in that we had never known just what value our efforts were to the overall program.

The Radiation Safety Officer, Lieutenant D. R. Shields, was sent TDY to the Los Alamos Scientific Laboratory to determine the effect of the neutron field on personnel exposed in sampling Project KIWI A PRIME. Neutron radiation is a phenomenon which occurs only at the time of the detonation (sic) of fissionable material and only shortly thereafter. Consequently, sampling aircraft and crews were not previously exposed to it. In the KIWI tests; however, detonation (sic) is taking place within the reactor continuously and neutron radiation is continually produced, and the aircraft and crews are required to fly in neutron field. New measuring equipment and procedures are being devised to reduce the hazard encountered during the last test. In conjunction with this, appointments were made for those personnel participating in KIWI A THREE to go through the Human Body Counter at Los Alamos prior to and after the projected tests. All aircraft were given a complete radioactivity check on 19 September (1960) and all readings were below the minimum radioactive levels.

Deployment to accomplish its sampling missions for Project MUSIC MAN became routine with the squadron, and although the first mission to East Sale, Australia, was accomplished promptly and efficiently, subsequent deployments showed improvement. Preparation necessary for such a deployment included: The five B-57B aircraft for the Australian deployment, one of which was to be a spare, modified for one UHF, on VHF and the new Single Side Band HF (communications) equipment. The aircraft were outfitted with tip fuel tanks and were test flown at least twice. After each flight, personnel adjusted and rechecked all the equipment and the single side band equipment. Modification of the antenna loading configuration of the single side band set was necessary. All were in perfect operating order for the trip.[24]

Every item possible was preplanned and supply prepackaged in aluminum flyaway kits, made lists of the location of all items, and marked all the kits. Each of the two C-124 aircraft was loaded with the kits according to the accessibility requirements enroute. Easy access to tools and equipment from the kits facilitated enroute maintenance.[25]

On 17 October 1960, the two C-124 Globemaster aircraft left Kirtland with some 47,000 pounds of cargo, 33 enlisted and 3 officer personnel. The following day, five B-57B aircraft departed, one of which as spare went only as far as Travis Air Force Base, California. The four deploying B-57B and the two C-124 aircraft arrived in Australia six days later, having flown more than 8,000 miles. The total enroute flight time for the B-57 aircraft was 23 hours and 45 minutes.[26]

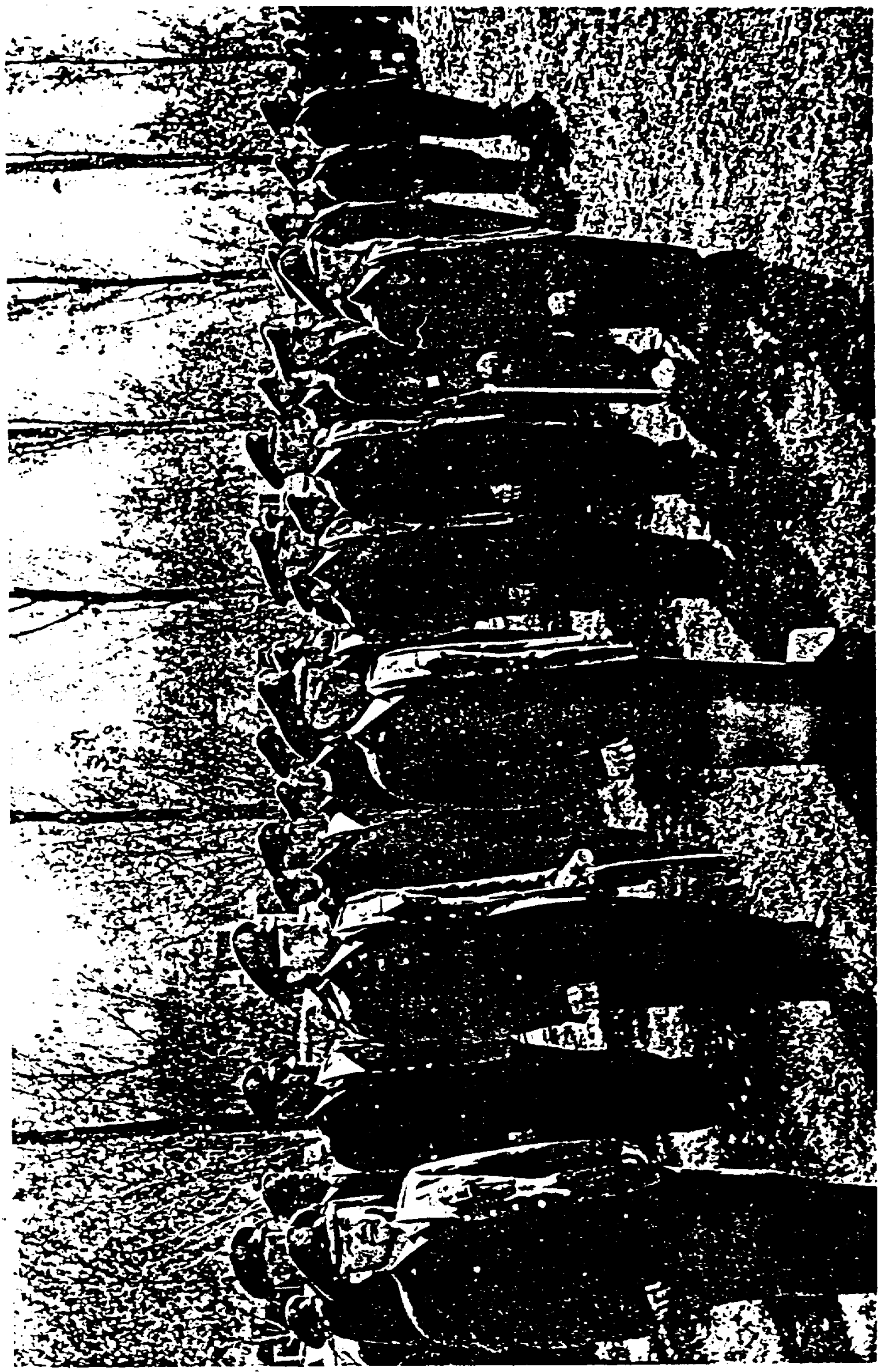
The longest overwater leg, that from Travis to Hickam Air Force Base, Hawaii, a distance of 2,135 nautical miles, was flown with a 30-knot headwind component, in 5 hours and 30 minutes. It was flown without having to jettison the wing tip fuel tanks, as was originally planned for, with considerable saving for Air Force.

All the overwater legs of the deployment flew in coordination with the Strategic Air Command U-2 aircraft deploying under CROW FLIGHT VI, thus affording the B-57 aircraft the search and rescue coverage given the Strategic Air Command. Two C-54 aircraft were in orbit on all the legs except from Hickam to Canton Island, where only one rescue aircraft deployed. Typical of the coordination required on an operation of this magnitude and participated in by the variety of aircraft and missions thereof, was the Travis to Hickam leg of the deployment. The four B-57 aircraft and one SC-54 aircraft were prepositioned at Travis Air Force Base, on 18 October 1960. The problem was to coordinate the passage of the U-2 aircraft over an orbit point of the SC-54 on the Los Angeles to Honolulu track and allow time for the rescue aircraft to move from the Travis to Honolulu track by the time the B-57 aircraft passed. This was accomplished as the SC-54 departed Travis approximately one-half hour before the first U-2 left its home station at Laughlin Air Force Base, Texas. The four B-57 aircraft departed Travis in formation one-half hour before the first U-2 passed over the Long Beach very high frequency omnidirectional range. The SC-54 was in orbit on the Los Angeles to Honolulu track when all three U-2 aircraft passed overhead, then when the last U-2 was 250 miles along the track toward Ocean Station November, the SC-54 moved up to the vicinity of the Travis to Honolulu track for passage of the B-57 aircraft. The coordination was perfect, and valuable navigational assistance was obtained from the rescue aircraft. All the deploying aircraft then passed over the Ocean Station Vessel November and a second SC-54 midway between the vessel and Honolulu. Radio contact between all the aircraft and the vessel was good, and the B-57 flight was made without incident.[27]

From the time of its organization until the 4926th Test Squadron (Sampling) transferred from its membership with the Air Force Special Weapons Center, it engaged in sampling operations for the following nuclear, dust, and weather sampling missions:[28]

Date	Operation	Location
1953 Apr-July	UPSHOT/KNOTHOLE	Nevada Test Site
1953 Sep-Oct	TIGER CAT	
1954 Feb-June	CASTLE	Eniwetok
1955 Jan-May	TEAPOT	Nevada Test Site
1956 Apr-Aug	REDWING	Eniwetok
1957 Apr-Oct	PLUMBBOB	Nevada Test Site
1957 May-Sep	CREWCUT	Central America
1958 Mar-Oct	HARDTACK	Phase I, Eniwetok Phase II, Nevada
1958	HONEST JOHN	
1959	PROJECT ROVER	Nevada Test Site
1959	60 ESCO (Special Fuze Project)	Kirtland AFB
1959-60 June	PROJECT JAGUAR	Point Mugu, Calif.
1960 Jan-Mar	SUNDAY PUNCH I	Kirtland AFB
1960 Jan-Mar	GOLF BALL	Australia
1960 Apr-June	SUNDAY PUNCH	Kirtland AFB
1960 June-July	KIWI A PRIME	Nevada Test Site
1960 Apr-June	MUSIC MAN I	South America

In July 1956, during the short period when Colonel Fred H. Newman was commander of the 4925th Test Group (Atomic), he recommended the 4926th for the Air Force Outstanding Unit Award. He outlined the squadron's



Outstanding Unit Award Ceremony, reviewing officers. First two rows, left to right: Colonel J. A. Watkins, ARDC; Major M.J. Speer, ARDC, holding the award; Lieutenant General T.S. Power, ARDC; Colonel W.B. Kieffer, AFSWC; Colonel J.S. Samuel, AFSWC; Colonel H.G. Hamby, AFSWC; Brigadier General W. M. Canterbury, AFSWC. 16 November 1956.

history and pointed out that the organization had worked under extremely adverse conditions which involved mass squadron movements, long periods of temporary duty, and hazardous working and flying conditions. Between 1 April 1953, when it was organized, and 1 June 1955, the squadron flew 6,238 hours with only two accidents, both nonpilot errors. It had no ground safety accidents on or off duty, and no absences without leave or courtmartial. These facts, the Colonel indicated, reflected the high morale and discipline existing within the 4926th Test Squadron (Sampling).[29]

The Secretary of the Air Force, Donald A. Quarles, directed that the award be made, and on 23 October 1956, the Department of the Air Force issued the required general order. While operating under adverse working conditions and flying hazardous missions, the squadron collected upper air gaseous and particulate samples from nuclear and thermonuclear detonations the order stated, and had ". . . compiled an enviable record, meeting and exceeding every requirement."[30] On 16 November 1956, Lieutenant General Thomas S. Power, Commander of Air Research and Development Command, presented the citation by attaching the streamer, designated the Air Force Outstanding Unit Award, to the squadron's colors, following a parade in the squadron's honor.[31]

Recent Special Assignments

In addition to performing such specialized missions as had become routine with nuclear detonations, it became a primary and continuing mission of the sampling aircraft and crews to conduct daily surveillance along the periphery of the Asiatic mainland; a weekly schedule of gaseous and particulate samples from four separate latitudinal areas of the earth; and readiness for immediate deployment of a force capability to any accessible region of the globe for intensified maximum collection of nuclear samples or debris connected with foreign nuclear detonations.[32] Plans for the world-wide sampling program were drawn up jointly by representatives from the Air Force Technical Applications Center, Strategic Air Command, Air Research and Development Command, Alaskan Air Command, the Pacific Area Command, Air Materiel Command, Military Air Transport Service, and the Air Weather Service. Authority for the Ad Hoc Committee directed: Review problem areas and make recommendations to the Air Staff on the best ways and means to implement an expanded program in response to new and expanded requirements from Air Force Technical Applications Center.[33]

Resources available for implementing the expanded program consisted of eight RB-57B and two B-57C aircraft from the Air Force Special Weapons Center; six RB-57A aircraft assigned to Pacific Area Command, Air Force; four B-57 aircraft of the Alaskan Air Command; and eighteen WB-50 aircraft assigned to the Air Weather Service. Altogether 174 officers, 760 airmen and 9 civilian specialists were available for accomplishment of the program.[34]

The daily surveillance mission required coverage from 15 degrees north latitude (Philippines) to 55 degrees north latitude (tip of the Aleutians) at the 700-millibar and either the 400 or 500-millibar levels. Samplers directed two round-robin missions each day from Yokota, Japan, one northeast and one southwest, outbound at one altitude and inbound on the alternate altitude. The purpose of the flights was to collect daily particulate samples emanating from the Asiatic mainland in order to detect possible nuclear events not otherwise picked up by the early warning system.[35]

The 4926th Test Squadron also collected gaseous and particulate samples from each of the four separate latitudinal areas: north of Eielson Air Force Base, Alaska; south of Yokota, Japan; north of Laughlin Air Force Base, Texas; south of Andersen Air Force Base, Guam; and from East Sale, Australia. Samples were collected each 15 days at all four locations. On each alternate 15-day schedule, a modified profile sampling was made. During each May and November, the sampling program increased so as to obtain profile samples each week (five missions each month in lieu of the routine two missions per month for the other ten months).

Assumptions which guided the enlarged sampling program included,

(a) A total of 35 foreign nuclear tests would be conducted annually.

(b) Tests would be conducted at a rate of not more than two events in one seven-day period.

(c) Tests would be conducted in series of not less than five events each series.

(d) The maximum sortie requirement for each foreign event was estimated to be two tropospheric flights and three stratospheric flights per day for a period of ten days after each event.[36]

Strategic Air Command, although explaining that insufficient time for final determination had been given, tentatively agreed to support and maintain two U-2 aircraft at each operating location on a temporary duty basis as tactical aircraft required returning to zone of interior bases for inspection and repair as necessary (IRAN) programs. Ground handling support equipment was permanently assigned to operating locations and a limit of temporary duty for personnel was 90 days out of each 15 months. The Strategic Air Command agreed to procure four additional P-2 platforms needed for mission work, and four additional "Clarks." The engine overhaul program was enlarged to provide two buildup engines at each location and the proposed manning documents were approved and filled; replacement personnel would not be below the three-level qualified. At least one temporary operating location other than one of the permanent operating locations was deployed each year for a period of approximately 30 days. Quality control teams visited each operating site periodically to insure compliance with approved maintenance procedures.

But before Strategic Air Command could fulfill the requested obligations, it required the following: Increased assignment of U-2 aircraft to 4080th Strategic Reconnaissance Wing to total of 28; increased manning by 240 personnel slots, with input of critical career categories to begin immediately; and an increase in authorization and availability of four P-2 platforms, four Clarks, and four mobile vehicles.

Strategic Air Command insisted on retaining operational control of aircraft furnished for the increased Technical Applications Center mission.[37] Technical Applications Center officials detailed a new "Single Manager" concept. Under this plan:[38]

(a) Air Weather Service mission directives were to be amended to include functional responsibility for weather reconnaissance, air sampling, and daily surveillance.

(b) Air Weather Service would be responsive to weather reconnaissance requirements of appropriate Air Force and defense agencies.

(c) Air Weather Service would be responsive to the sampling requirements of Technical Applications Center, the Atomic Energy Commission, the national space agency and such other governmental agencies as might be involved in approved government sampling programs.

(d) When possible Air Weather Service would be responsive to other weather or dual utilization requirements of other Department of Defense agencies providing no conflict with basic mission responsibility was involved.

(e) Air Weather Service would be the single point of contact for the programming and management of all aerial sampling requirements.

(f) All aircraft, manpower and specialized equipment associated with the world-wide air sampling and weather reconnaissance functions would be assigned to and controlled by Air Weather Service, with the following exceptions: U-2 aircraft, manpower, and specialized U-2 equipment remained assigned to Strategic Air Command.
However, when required in the air sampling functional mission, these

Strategic Air Command resources were to be responsive to control Air Weather Service mission requirements for air sampling. The intent of this arrangement was to preserve the Strategic Air Command ownership and control of the U-2 aircraft but also providing for the integration and effective utilization of this indispensable aircraft in the world-wide sampling functions.

Reorganization plans proceeded under the "Single Manager" concept with an alternate reorganization possible should the 4926th Test Squadron (Sampling) be required to remain at Kirtland.[39] Other than those missions directed by the Technical Applications Center, the air sampling force was to maintain capabilities to serve the Atomic Energy Commission, the Los Alamos Scientific Laboratory, and other appropriate agencies. By Air Force directives, that capability had to be retained notwithstanding a moratorium on testing, or the international ban on nuclear testing projected concurrently.

Plans estimated that 1,000 flying hours could be made available to the increased Technical Applications Center mission without hindering other operations. Alaskan Air Command claimed that requirements consumed only 30 per cent of the capability of the B-57 aircraft requested so it was tentatively agreed that command would retain control of those aircraft.[40]

Alternate plans for accomplishment of the increased mission were submitted. The first proposal for Fiscal Year 1962-1963 had resources and costs as follows:[41]

(a) Aircraft, flying hours and operating costs:

Aircraft	Annual Flying Hours	Pol-Maint Cost/Hour	Direct Operating Cost
20 B-57	8,374 (7,320)	$345.38	$2,892.212
5 C-130	6,325 (6,131)	281.42	1,779.982
12 WB-50	10,494	385.37	4,044.073
		Total	$ 8,716.267

Hours shown in parenthesis were total hours required to perform stated mission; however, the concept of four sampling units with identical capabilities required additional hours to be programmed at Yokota and Guam, increasing the B-57 and C-130 totals as shown. This concept was in accordance with the Air Force Technical Applications Center desires.

(b) Modifications of aircraft:

Aircraft	Type of Modification	Cost
B-57	Installation of doppler navigation equipment in 6 aircraft (3-Alaska, 3-Guam) @$34,600 each plus 2 bench mockups @$27,000 each	$261,600
C-130	Prototype sampling modification of one aircraft @ $100,000 plus follow on modifications of four aircraft @ $75,000 each	400,000
	Total	$661.600

(c) Manpower required to support this proposal, showing net change in present manning for the Air Weather Service:

	Officers	Airmen	Civilians
Required	189	733	10
Net Change	+105	+358	-

Mobility was an essential element of this plan. The variables associated with foreign nuclear events made it possible to anticipate the geographical site for each detonation. Thus, a built-in capability to react on minimum notice was critical to successful reconnaissance of foreign nuclear activity. No other aircraft in the current Air Force inventory was more ideally suited to this particular mission than the C-130. Moreover, as a basic part of the production sampling operation, the C-130 was dually used as a 15,000-foot sampler plus back-up for 25,000 feet and for limited DUCKBUTT/RESCUE purposes.

Specific flying hours for full mobility-rescue capability were not included in flying hour computations; however, it contemplated that hours programmed for production sampling were available to support mobility requirements if production sampling was temporarily suspended due to foreign event coverage. Time phasing for implementation was to be as follows:

(a) Latitudes 30° - 35° N.

(1) ~~Start~~ B-57 operations from Yokota AB, Japan in July 1961.

(2) Start U-2 operations from Laughlin AFB, Texas, in July 1961 simultaneously with B-57 flights from Japan.

(3) Phase in C-130 operations at Yokota AB as soon as aircraft complete modification, estimated to be September 1961 allowing six months lead time.

(b) Latitudes 10° - 15° N.

(1) Start B-57 and U-2 operations from Andersen AFB, Guam in July 1961.

(2) Phase in C-130 operations at Andersen AFB as soon as aircraft complete modifications, estimated to be September 1961.

(c) Latitudes 70° - 75° N.

(1) Start B-57 and U-2 operations from Eielson AFB, Alaska in September 1961, or sooner if facilities can be made available.

(2) Phase in C-130 operations at Eielson AFB as soon as aircraft completes modification, estimated to be October 1961.

(d) Latitudes 40° - 45° S.

(1) Start complete operations from Australia in FY 2/62, assuming diplomatic arrangements have been completed by FY 1/62.

(e) Mobility force.

(1) B-57 and WB-50 aircraft will be ready at McClellan AFB, California in July 1961.

(2) C-130 will be phased in as soon as aircraft completes modification, estimated to be October 1961. . . . . .

The conclusions reached by the AD Hoc Committee in February 1961 were:[42]

(a) Immediately - Continue WB-50 surveillance operations from Japan and maintain WB-50 mobility force at McClellan AFB.

(b) July 1961 - Start B-57 operations from Japan and Guam; establish B-57 mobility capability at McClellan AFB.

(c) September 1961 - Start B-57 operations from Alaska and phase in C-130 operations at Japan and Guam.

(d) October 1961 - Phase in C-130 operations in Alaska and establish C-130 capability at McClellan AFB.

(e) November 1961 - Start B-57 and C-130 operations from Australia.

(f) Convert to WB-47/WC-130 operations as soon as aircraft can be made available.

Thus was set in motion the sequence of events which led up to the operations known as MUSIC MAN and CROW FLIGHT as well as the air sampling operations which made it possible to detect foreign nuclear blasts; to determine the yield of those blasts, the efficiency of the device tested, and even the mechanical and physical means used to cause the detonation.[43]

KIWI

During the summer and early autumn, 1960, tests of two nuclear powered reactors under Project ROVER, KIWI A-PRIME and KIWI III were conducted by the Atomic Energy Commission-Los Alamos Scientific Laboratory. Despite much and repeated delays, when the reactors finally operated, the B-57 crews of the 4926th accomplished sampling missions with no operational difficulties.[44]

For the sampling of KIWI A-PRIME, a trail formation, race-track pattern sampling technique was used. Following the firing of the first jet-assisted takeoff, the airborne control aircraft orbiting in the area adjacent to the reactor test cell informed the four sampler aircraft to commence the sampling operation as soon as the exhaust cloud reached a minimum safe altitude. This was determined to be approximately 6,000 feet mean sea level, or 2,000 over the reactor. The jet-assisted takeoff fired in banks of five at one minute intervals for a period of nine minutes. During this time, the expelled hydrogen was ignited by the acetylene flare as it left the nozzle of the reactor and forced the exhaust and smoke aloft to an altitude of approximately 3,000 feet above the reactor. The wind being relatively calm, the smoke cloud hovered over the reactor for a short time, then started to drift off in a northeasterly direction. The jet smoke was the only means used to identify the exhaust cloud and debris. During "runs" by the sampler aircraft, the pilots relayed the radiation level and dosage readings from cockpit instruments to the airborne control aircraft. These were noted and monitored by the scientific controller riding in the rear cockpit of the control aircraft. Upon dissipation of the identifying cloud, the samplers continued to track the exhaust debris by cockpit instrumentation until they could collect no further samples. After approximately five minutes at high power, the fuel modules in the reactor started to deteriorate and expel large pieces of carbon from the nozzle. The pieces were propelled approximately 300 feet into the air and then fell to the ground around the reactor. There was no contact of these pieces with the sampler aircraft.

It was decided on a follow-up meeting with the KIWI test director that these fuel elements had an extremely high radiation count. In the event one of these elements was ingested by a jet engine or adhered to the airframe, except fuselage cockpit area, the aircraft would have to be abandoned by the aircrew within five minutes or suffer unduly high radiation dosage. Preventive measures were followed to preclude contact with these or similar expelled parts of the reactor.[45]

During KIWI III, sampling procedures were similar, except that pilots flew at not less than 750 feet above the reactor and 750 feet to one side to avoid any possible contact with the solid debris. The Special Weapons Center approved a spare B-57 for use as a neutron field sampler, at no charge to the Atomic Energy Commission.

Neutron radiation dosages were unrecorded because of the instantaneous nature of such emanations. That source of radiation had been discovered by analysis of the standard beta-gamma film badge and the neutron field did not exist during the critical operation of the reactor. Further, there were no standards nor basis of comparison to establish dosage limitations for the exposed aircrews. "All criteria and standards established by Los Alamos Scientific Laboratory were met or exceeded," the notation in the project officer's management report commented.[46]

SUNDAY PUNCH

The 4926th Test Squadron (Sampling) conducted sampling surveillance in support of the Technical Applications Center enlarged mission under the code name of SUNDAY PUNCH, a part of the larger Project CREWCUT. The operation had six missions, each conducted with three B-57 samplers. Both the 4926th and the 4080th Strategic Reconnaissance Wing supplied aircraft and crews. Conducted in close cooperation with the Technical Applications Center Western Field Office, each of the sampling squadrons accomplished half of the sampling missions.

Samples were taken at altitudes of 15,000 feet, 25,000 feet, and 40,000 feet and at three levels above 40,000 feet; the 4080th Strategic Reconnaissance conducted sampling at the higher levels because it had the B-57D aircraft. Samples were made at approximately 35 degrees north latitude and 105 degrees west latitude. The test squadron provided one spare aircraft.[47]

The two sampling units conducted follow-up of SUNDAY PUNCH during early summer, 1960 (10 May through 15 June). Samples collected during those two phases consisted of gaseous samples compressed to 6,000-pounds-per-square-inch pressure, with a minimum acceptable pressure of 5,000-pounds-per-square-inch pressure.[48] SUNDAY PUNCH III and IV followed in the fall of 1960 and spring of 1961.[49]

MUSIC MAN

The MUSIC MAN series of sampling operations were the world-wide phases of detecting sampling activities, the Strategic Air Command counterparts of which were dubbed CROW FLIGHT.[50] The mission of the 4926th Test Squadron (Sampling) was essentially the same for all series:

(1) Organized Flight C, 4926th Test Squadron (Sampling). This flight consisted of aircraft and personnel required to perform the mission. Flight C disestablished on completion of this mission.

(2) Furnished four NB-57B aircraft to perform required sampling missions. All aircraft were programmed so that they deployed, flew the necessary missions, and redeployed without requiring a periodic inspection.

(3) Responsible for deploying and redeploying mission aircraft. Foreign clearance was obtained in accordance with AFR 60-8 and the Foreign Clearance Guide.

(4) Responsible for organizational maintenance of deployed aircraft, and such further maintenance as was within their capability.

(5) Responsible for administration of deployed personnel. Each member participating in the sampling series was cautioned if questioned as to his destination or where he had been "I am assigned to one of the USAF units carrying out a special world-wide operation to check on weather and the composition of the atmosphere to determine the reservoir of radio active debris and the rate of fallout."
Deployment was to East Sale Air Base, Australia.

MUSIC MAN III was a repetition of previous weather-radioactive debris sampling missions and was also enacted at East Sale Air Base, Australia.

GOLF BALL

The Air Force placed a high priority requirement on the 4950th Test Group (Nuclear) for particulate and gaseous atmospheric sampling in the North African area for a 15-day period occuring sometime between 1 February and 1 March 1960. This coincided with French experiments being conducted in the Sahara. The 4926th deployed four JB-57B samplers to Wheelus Air Base, Libya, and collected both particulate and gas (compressed) samples.[51]

Squadron Transferred to Military Air Transport Service

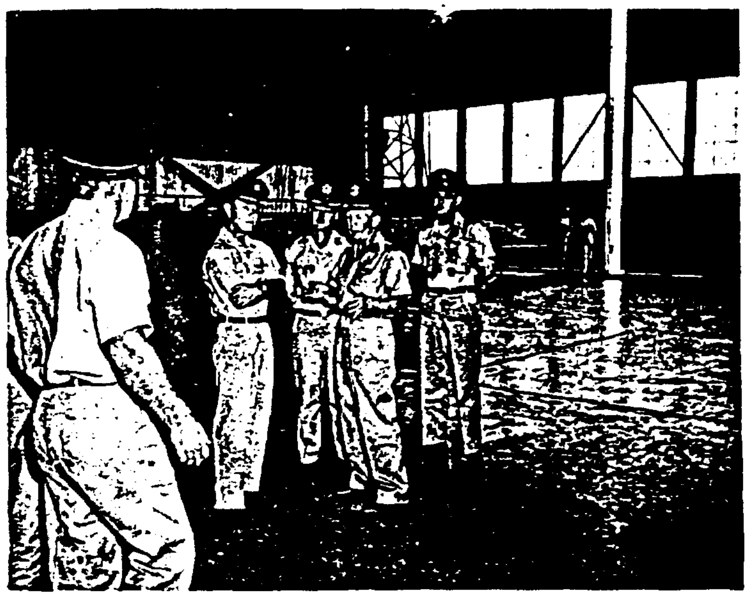
Early in 1961, steps were instituted which within a year transferred the test squadron from the Air Force Special Weapons Center to the Military Air Transport Service. Because of the demand for the service of the squadron by the Air Weather Service, by the Defense Atomic Support Agency, and the Atomic Energy Commission, and by Air Force Technical Applications Center plans were formulated to transfer the squadron as early as January 1961.[52] Negotiations for the transfer continued throughout the early months of 1961 and officials of both parties set a target date of 1 August 1961 for the transfer. The transfer and redesignation of the 4926th Test Squadron (Sampling) was affected on 16 August 1961.[53] The new designation for the unit was 1211th Test Squadron (Sampling), (MATS).

The final history of the 4926th Test Squadron told of this transition:[54]

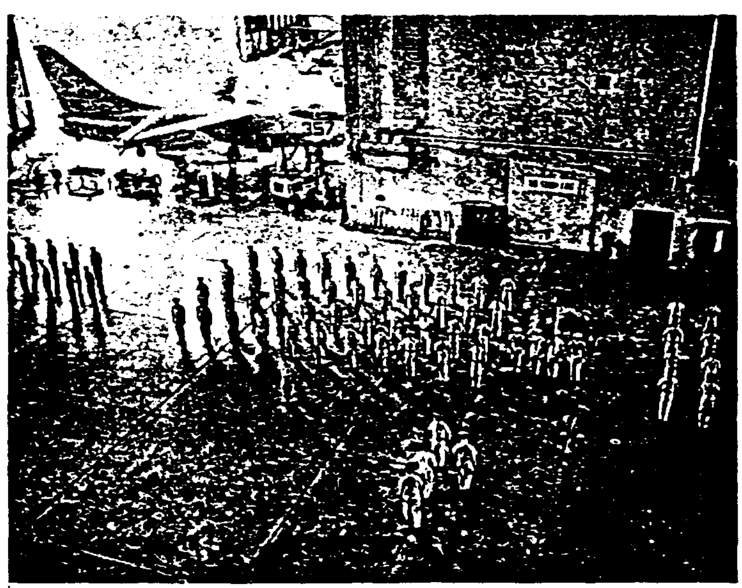
The mission of the 1211th Test Squadron (Sampling) remained two-fold and unchanged: (1) to provide a flight test organization which was manned, trained, and equipped to collect samples of the atmosphere in areas of radioactivity resulting from ground or air detonation of nuclear devices; and, (2) to investigate and collect particulate air samples at specified altitudes and areas. This included investigation of the exchange of air between the stratosphere and the troposphere in the vicinity of the jet stream. Because of the moratorium on atomic and nuclear testing most of the mission assignments were related to United States Weather Bureau programs. Air Force officials concluded that mission nature was more related to the duties and responsibilities of the Air Weather Service than those of Air Force Systems Command. Staff members from headquarters, 9th Weather Reconnaissance Group, McClellan Air Force Base, and Air Weather Service, Scott Air Force Base, Illinois, made preliminary inspections of the squadron beginning on 2 August and reorganization of the squadron followed in accordance with Air Weather Service Manual 66-2 with the orders that the changes take place on 16 August 1961. On 15 August, Brigadier General Normal L. Peterson, Commander, Air Weather Service, and his staff arrived at Kirtland Air Force Base for the purpose of change-of-command ceremony.

Colonel Harvey P. Hall, Commander, 9th Weather Reconnaissance Group, arrived during the afternoon of 15 August. The next morning, 16 August, a briefing was given in the squadron briefing room from 0800 to 0900 hours for General Peterson, his staff, and Colonel Hall. Squadron Commander, Major Arthur L. Consta, welcomed the group and presented a condensed historical review of nuclear testing. He described squadron mission, major operations, and activities, with outstanding accomplishments and awards. Captain Douglas G. Ludlam, Jr., executive officer and chief navigator, gave a synopsis of each major operational accomplishment. An inspection of squadron facilities, equipment, including B-57 aircraft, was made following the briefing. Parade and inspection preceded change-of-command ceremony held on the main hangar floor. Invitation to a celebration party was extended by the squadron airmen to all guests and participating personnel. With change-of-command, the 1211th Test Squadron (Sampling) became a tenant at Kirtland.

In general summary, the report concluded, "Squadron condition was considered excellent. Morale and esprit de corps were exceedingly healthy and vigorous as the 1211th Test Squadron (Sampling) continued to function with the same traditional pride which herald accomplishments of jobs well done."



Major General Charles M. McCorkle, Commander of AFSWC; Brigadier General Normal L. Peterson, Commander, Air Weather Service; Lieutenant Colonel Joseph K. Byrne, Commander, 4950th Test Group (Nuclear); Captain Billie B. McLeod, Aide-de-Camp, at Change of Command ceremonies for the 4926th Test Squadron



Change of Command ceremonies for the 4926th Test Squadron (Sampling).

CHAPTER XIII

NOTES

1. Memo. to Col. W. B. Reed, AFOAT-1, prep. by Lt. Col. J. J. Cody, Jr., AFOAT-1, 12 Feb. 1951, subj.: Preliminary Narrative Report on AFOAT-1 Participation in Operation RANGER, see App.

2. Interview with Col. Paul H. Fackler, AFOAT-1, conducted by Warren E. Greene, AFSWC Hist., 24 July, 1957, see App.

3. DF, Col. E. W. Kesling, Ch., Test and Eval. Div., DCS/O, to DCS/O, 19 Dec. 1952, subj.: Semi-Monthly Activity Summary, Test and Evaluation Division, DCS/O, for period ending 12 Dec. 1952.

4. Ltr., Lt. Col. J. F. Starkey, Ch., Spec. Proj. Br., DCS/O, to Test and Eval. Div., DCS/O, 30 Dec. 1952, subj.: Semi-Monthly Activity Summary for Period Ending 26 Dec. 1952.

5. Ltr., Col. D. E. Hooks, CofS, AFSWC, to CG, ARDC, 21 Jan. 1953, subj.: A Concept of Operation for Radioactive Cloud Sampling in Support of AEC, see App.

6. Study, "A Concept of Operation for Radioactive Cloud Sampling in Support of AEC," prep. by SWOTP, AFSWC, 31 Dec. 1952, see App.

7. Ltr., Col. Hooks to CG, ARDC, 21 Jan. 1953, see App.

8. Interview with Col. Fackler, 24 Jul. 1957; interview with Dr. Harold F. Plank, J-11 Div. Leader, LASL, 25 Aug. 1957, see App., passim.

9. Ltr., Gordon Dean, Ch. AEC, to Hon. Robert LeBaron, Ch., Mil. Liaison Comm. to the AEC, 9 Feb. 1953, subj.: Permanent Cloud Sampling Unit, see App.

10. ARDC GO No. 25, 27 Feb. 1953.

11. ARDC GO No. 28, 18 Mar. 1953, see App.

12. 1st. Ind., (ltr., Col. Hooks to CG, ARDC, 21 Jan. 1953), Col. Ernest R. Manierre, Asst. Dep. for Ops., ARDC, to CG, AFSWC, 15 Apr. 1953, see App.

13. Ltr., Maj. Herbert W. McQuown, Cmdr., 4926th Test Sq.(S), to Cmdr., 4925th TG (A), 30 Apr. 1953, subj.: The 4926th Test Squadron (Sampling), see App.

14. Officers' Roster, AFSWC, 15 May 1953; rpt., "Operation UPSHOT/KNOTHOLE, Nevada Proving Grounds, March-June 1953, Report to the Test Director, Aircraft Participation," prep. by Lt. Col. Fackler, see App.

15. Officers' Roster, AFSWC, 15 July 1953.

16. Comment No. 2 (DF, Ch., Jt. Fld. Ops. Br., HEADAFSWC, to Cmdr., AFSWC, 29 Nov. 1955, subj.: (C) Close-in Gas Sampling), Capt. Louis B. Christenson, Adj., to Cmdr., AFSWC, 12 Dec. 1955, see App.; MSgt. Max Gerster, The Special Weapons Center and Atomic Testing, AFSWC Hist. Div., Jan. 1957; "Final Report of the Commander, Air Task Group 7.4, Operation CASTLE," n.d., 1-3, in Hist. Div. files.

17. Rpt., "Final Report for June 1958, (Operation HARDTACK)," prep. by TG 7.4 (P), see App.

18. Staff Study, "Planning for Future Test Programs," n.s., 19 May 1953, see App., passim.

19. Rpt., "Two Base Concept," prep. by MSgt. Leland B. Taylor, AFSWC Hist. Div., excerpted from unit histories, 4926th Test Sq. (S), 1957-1960, passim. AFSWC Hist. Div. files.

20. Ibid.

21. Ibid.

22. Ltr., Dr. Harold F. Plank, J-11, LASL, to Alvin C. Graves, J-DO, LASL, 7 July 1954, subj.: Request for Direct Liaison Between LASL and the 4926th Test Squadron (Sampling), Kirtland AFB, see App.

23. Unit History, 4926th Test Squadron (Sampling), Aug-Dec. 1950, Hist. Div. files, 4926th Test Sq. (S).

24. Ibid.

25. Ibid.

26. Ibid.

27. Ibid.

28. Interview with Capt. Gordon E. Stalcup, Hist., 4926th Test Sq. (S), conducted by MSgt. Taylor, 18 Oct. 1961, Hist. Div. files, 4926th Test Sq. (S).

29. Ltr., Col. F. H. Newman, Cmdr., 4925th Test Gp. (A), to Cmdr., AFSWC, 12 July 1956, subj.: Recommendation for the Air Force Outstanding Unit Award, in Hist. Div. files, Sampling.

30. USAF GO No. 65, 23 Oct. 1956, see App. "The 4926th Test Squadron (Sampling) distinguished itself by outstanding achievement in aerial and ground support of classified Atomic Energy Commission and AFOAT-1 projects. By collecting upper gaseous and particulate samples after detonation of nuclear and thermonuclear devices, the 4926th Test Squadron (Sampling) compiled an enviable record, meeting and exceeding

every requirement. Working under extremely adverse conditions, involving mass squadron movements, long periods of temporary duty, and hazardous flying and working conditions, the 4926th Test Squadron (Sampling) accomplished its mission in a superior manner. This outstanding accomplishment achieved by all members of this organization reflects great credit upon themselves and the United States Air Force."

31. Personnel of the 4926th were authorized to display the appropriate ribbon on their uniforms. See, History of the Air Force Special Weapons Center, 1 July - 31 December, 1956, pp. 8-11.

32. Rpt., "USAF AD HOC Committee Determinations Concerning World Wide Sampling Requirements," prep. by Hq., AWS, MATS, 3 Feb. 1961, Sec. II, Hist. Div. files, Sampling.

33. Ibid.; TWX, AFOOP-SA 65836, Hq., USAF, to Dist., n.d.

34. Rpt. "USAF AD HOC Committee Determinations Concerning World Wide Sampling Requirements," 3 Feb. 1961, Sec. III.

35. Ibid., Sec. I.

36. Ibid.

37. Ibid., Sec. III, atch. 1 (TWX, DOCORS 0506, SAC to AWS, 25 Jan. 1961).

38. Ibid., Sec. IV.

39. Ibid.

40. Ibid., Sec. V.

41. Ibid., Sec. IV, Proposal No. 1

42. Ibid., Conclusions and Recommendations.

43. Interview with Paul W. Guthals, J-11, LASL, conducted by MSgt. Taylor, AFSWC Hist. Div., 12 Sep. 1961.

44. Final Rpt., "Project KIWI-A, 1959," prep. by 4950th TG (N), n.d., 5-7, 12; Final Rpt., "Project KIWI A PRIME: KIWI A THREE, 1960," prep. by 4950th TG (N), n.d., 7-9, 14-15, AFSWC Hist. Div. files.

45. Interview with Mr. Guthals, 12 Sep. 1961.

46. Mgt. Rpt., 921-D-0000-02141, MR-3, "KIWI A PRIME," 12 July 1960, see App.

47. Opn. Order 4-59, pub. by 4950th TG (N), 24 Sep. 1959, see App.

48. Opn. Order 4-60, pub. by 4950th TG (N), 6 May 1960, see App.

49. Opn. Plan 7-60, "SUNDAY PUNCH III," prep. by 4950th TG (N), 12 Oct. 1960; Opn. Plan 10-61, "SUNDAY PUNCH IV," prep. by 4950th TG (N), 3 Apr. 1961; interview with Capt. Gordon E. Stalcup, 4926th TS (S), conducted by MSgt. Taylor, 12 Oct. 1961, AFSWC Hist. Div. files

50. Opn. Plan 6-60, "MUSIC MAN," prep. by 4950th TG (N), 22 Aug. 1960, 3; Opn. Plan 4-61, "MUSIC MAN III," prep. by 4950th TG (N), 6 Mar. 1961, AFSWC Hist. Div. files.

51. Opn. Order 1-60, pub. by 4950th TG (N), 7 Jan. 1960, AFSWC Hist. Div. files; Albuquerque Journal, 8 and 15 Feb. 1960.

52. Ltr., Lt. Col. Joseph K. Byrne, Cmdr., 4950th TG (N), to SWG, SWGD, and SWO, AFSWC, 13 Jan. 1961, subj.: Trip Report to Scott AFB, see App.

53. Memo. for Record, prep. by Lt. Col. James D. Davis, Dir. of Ops., 4950th TG (N), to SWS, 13 Jan. 1961, subj.: TWX MAXPD 1132G, MATS, Scott AFB, to AFSC, 27 July 1961; TWX, SCPMO 28 7-402, AFSC to AFSWC, 28 July 1961; TWX SCPMO-3-17-59, AFSC to AFSWC, 31 July 1961; and AFSC SO G-120, 7 Aug. 1961, see App.

54. Unit History, 4926th Test Sq. (S), Aug. 1961, passim., AFSWC Hist. Div. files, 4926th TS (S).

APPENDIX I: A LIST OF AIR FORCE SAMPLING PERSONNEL

Albright, Townsend L., Pilot
Alder, John L., Operations
Aragon, Christian D. S., Mun. Officer
Armbruster, F. S., Pilot

Balin, Harold E., Operations
Ball, F. W., Co-Pilot
Ballinger, R. W., Rad. Officer
Bennett, W. P., Pilot
Berger, Warren G., Operations
Berlin, Eli, Engineer
Beville, Ulmont U., Jr., Operations
Bickham, Claiborne F., A/C Maint.
Blanchard, L. C., Pilot
Booth, Robert J., A/C Maint.
Bounds, Malcolm S., Sr., Cmdr., 4926th
Braddock, J. E., Pilot
Brandt, John J., Pilot
Bremer, P. F., Pilot
Brooks, U. D., Pilot
Bruce, Lewis W., Operations
Bush, Fitzhugh G., Jr., Rad. Officer

Caldwell, James H., Operations
Callen, C. L., Engineer
Carey, Howard, Pilot
Castle, Henry G., Pilot
Cavanaugh, C. J., Pilot
Chestensen, Louis B., Mun. Officer
Christman, E. C., Pilot
Clarke, Raymond L., Nuclear Officer
Clausen, William J., Supply
Cody, Joseph J., Jr., AFSWC
Colthorp, E. D., Pilot
Conner, William R., Pilot
Consta, Arthur L., Pilot, Cmdr., 4926th
Corn, James T., Operations
Correll, H. M., Co-Pilot
Cotter, John A., Pilot
Crabtree, Booth A., Rad. Observer
Cross, John C., Administrative
Custer, R. C., Pilot

Davis, Thomas W., Pilot

Elam, Lewis A., II, Navigator
Ellingson, Quentin C., Operations
Emery, L. R., L. Scanner
Engbrecht, L. P., Rad. Officer
Ervin, Leon S., Operations

Fackler, Paul H., AFSWC
Faktorow, Saul, Operations
Fernandez, Manuel L., Navigator
Ferrell, Furman C., Pilot
Fettinger, George E., Operations

Gallagher, B. T., Rad. Officer
Gavin, E. M., Pilot
Gibson, Boyd E., Operations
Glantzburg, F. E., Pilot
Gleason, G. W. Pilot
Goodnight, James L., Pilot
Grayson, I. L., Pilot
Greaver, Earl R., Administrative
Guiling, John M., Pilot

Hall, Richard E., Pilot
Hall, W. W. Pilot
Hagan, Robert S., Pilot
Hardin, R. C., Pilot
Harding, Leslie S., Operations
Hardison, J. D., Pilot
Harper, Douglas A., Navigator
Harrison, Langdon D., Operations
Hart, Wallace L., Pilot
Harvey, B. E., Engineer
Henderson, Walter L., Nuclear Off.
Hennessey, Richard G., Pilot
Herry, Cale C., Pilot
Higgans, Richard W., Pilot
Hill, Donald D., Navigator
Hockett, Ray L., Jr., Operations
Holmes, James T., Operations
Hoover, Robert M., Operations
Hoskins, Ben B., Navigator
Houghton, K. H., AFSWC
Hurd, E. G., Pilot

Ivins, Joseph W., Pilot

Jackman, Thomas W., Pilot
Jacobie, Craig G., Operations
James, R. S., Jr., Pilot
Jensen, H. T., Rad. Officer
Jenson, J. T., Pilot
Jobe, Richard L., Navigator
Johnson, A. H., Rad. Officer
Johnson, Ralph W., Pilot
Justman, Arno R., Ground Radar

Kearnes, Archibald G., Mathematician
Kelley, Robert L., Operations
Kilborn, William J., Navigator
Kimball, Merl D., Jr., Operations
Kleinhelter, R. W., Pilot
Koller, Frank J., Jr., Pilot
Koski, E. M., Pilot
Krapcha, Edward L., Communications
Kregloh, E. R., Pilot
Kroll, F. C., Pilot
Krueger, R. D., Rad. Officer
Krull, Wilfred L., Pilot
Kuhn, Peter R., Operations

Lafollette, James E., Operations
Landry, Barney M., Operations
Larson, Walfred J., Operations
Lasher, Arnold E., Pilot
Lewis, George E., Mun. Officer
Lewis, Robert L., Supply
Lisella, John F., Pilot
Logsdon, Paul G., Jr., Operations
Lopez, J. C., R. Scanner
Ludlam, Douglas G., Navigator

Maiden, Robert A., Pilot
Markham, W., Pilot
Martin, R. H., Pilot
McCann, John W., Operations
McCluggage, R. D., Co-Pilot
McCrury, Jack H., Pilot
McCullar, Dalton W., Jr., Operations
McDonell, Miles C., Operations
McGehee, Sam D., Operations
McKeever, Francis B. Jr., A/C Maint.
McQuown, Herbert W., Cmdr., 4926th
Meinke, Francis B., Operations
Meroney, Virgil K., Pilot
Mitchell, Bobby D., Pilot
Mitchell, Finis A., Mun. Officer
Moore, Herman S., Pilot
Moyer, Larry E., Pilot

Newlen, C. S., L. Scanner
Nichols, James M., Nuclear Officer
Noll, J. R., Pilot

O'Bryan, R. R., Engineer
Ousley, Carl A., Cmdr., 4926th

Palmer, Paul W., Pilot
Papworth, Bryant R., Navigator
Patterson, Floyd H. Jr., Operations
Pearson, Peter J., Pilot
Peck, Lewis, Nuclear Officer
Penn, I. I., Co-Pilot
Penrose, R. C., Pilot
Peterson, A. A., Rad. Officer
Plutt, Philip E., Pilot
Polhemus, Hans E. Jr., Pilot
Porter, John M., Pilot
Price, Joseph L. Jr., Pilot,
Cmdr., 4926th
Putnam, Joseph W., Pilot

Racine, R., Pilot
Raines, G. A., Pilot
Rasnic, Charles R., Pilot
Regnier, Robert R., Pilot
Riker, George M., Navigator
Riley, Frank J., Operations
Robinson, Carl M., Operations
Robinson, J. P., Pilot
Rogers, J., Engineer
Rose, Wilbur S., Pilot
Rowan, John M., Operations
Roy, A. J., Pilot

Sams, William N., Communications
Schmidt, Norman, Operations
Schreiber, Ralph E., Operations
Scolavino, A., R. Scanner
Scott, John E., Rad. Officer
Seminare, Louie R., Pilot
Shields, Don R., Pilot
Simanonok, J. E., Pilot
Simpson, John F., Operations
Smith, A. E., Rad. Officer
Smith, Edward D., Operations
Smith, L. W., L. Scanner
Smith, M. R., Pilot
Spangler, William B., Pilot
Sprague, Glenn H., Pilot

Stacy, Kenneth Jr., Operations
Stalcup, Gordon E., Navigator
Stange, Laverne B., Pilot
Stanley, Neil D., Pilot
St. Claire, Donald R., Navigator
Steiner, M. A., Pilot
Stockman, Henry G., Pilot
Stockton, L., Rad. Officer
Stover, Ernest G., Rad. Officer
Stroup, Floyd B., Pilot
Sullivan, Joe F., Weapons Controller
Swink, Marvin N., Rad. Observer

Taylor, Raymond E., Rad. Officer
Tillotson, James H., Pilot
Trapp, David L., Nuclear Officer

Utterback, Robert W., Pilot

Villanueva, R. B., R. Scanner
Von Melker, R. A., Rad. Officer

Waits, Kenneth D., Pilot
Wakeman, John R., Pilot
Watkins, James A., Cmdr., 4926th
Weaver, Rubens S., Pilot
Whited, W. C., Pilot
Williams, G. V., Pilot
Wilson, Glenn R., Operations
Wilson, J. B., Rad. Officer
Wisniewski, Adam J., Operations
Wood, William E., Electronic Supt.
Woodring, D. V., Pilot
Wright, William H., Operations
Wright, W. N., Pilot
Wynns, Kelsey O., Pilot

- --

APPENDIX II: LIST OF SAMPLES TAKEN FOR EACH SHOT*

UPSHOT/KNOTHOLE

Shot	LASL F-84	LASL B-29	UCLRL
ANNIE	7	1	
NANCY	9		
RUTH	9	2	4
DIXIE	8	1	
RAY	9	2	6
BADGER	8	1	

Shot	LASL F-84	LASL B-29
SIMON	9	1
ENCORE	8	
HARRY	8	2
GRABLE	8	
CLIMAX	10	1

CASTLE

Shot	LASL F-84	LASL B-36	LASL B-29	UCLRL
BRAVO	12	2	1	
ROMEO	12	2	1	
KOON	8	2	1	6
UNION	7	1	1	
YANKEE	7	1	1	
NECTAR	7	2	1	

TEAPOT

Shot	LASL F-84	LASL B-36	LASL B-57	UCLRL
WASP	6			
MOTH	7			
TESLA				6
TURK				8
HORNET	5			
BEE	6			
APPLE I	5			
WASP PRIME	4			
HA	4	1	2	
POST	Unknown			6
MET	6		1	
APPLE II	7		1	
ZUCCHINI	7			

*The list includes those samples handled by Los Alamos Scientific Laboratory and the University of California Lawrence Radiation Laboratory. One aircraft retrieved one sample. In every case, however, samples taken will not necessarily correspond to the total number of aircraft participating in sampling operations. No records appear to have been kept for pre-1953 shots.

	F-84
WIGWAM, Operation	4

REDWING

	LASL		UCLRL
Shot	F-84	B-57	
LACROSSE	4	2	
CHEROKEE	4	4	
ERIE	4	2	
ZUNI			5
YUMA			6
SEMINOLE	4	2	
FLATHEAD	2	5	
BLACKFOOT	6	1	
KICKAPOO			6
OSAGE	6	1	
DAKOTA	2	5	
NAVAJO	4	5	
INCA			6
MOHAWK			6
APACHE			5
TEWA			6
HURON	2	4	

PLUMBBOB

	LASL			UCLRL
Shot	T-33	B-57	F-84	
BOLTZMAN		2	4	
FRANKLIN			5	
LASSEN				4
WILSON				11
PRISCILLA	2	2	2	
HOOD				6
JOHN		4		
KEPLER	4	2	4	
DIABLO				9
STOKES		2	4	
OWENS				8
SHASTA				7
DOPPLER		2	4	
FRANKLIN PRIME	4	1	3	
SMOKEY				10
GALILEO		2	4	
COULOMB B			4	
WHEELER				6

LA PLACE		5	
FIZEAU	2	4	
NEWTON	3		
WHITNEY			6
CHARLESTON			6
MORGAN			6

HARDTACK I

	LASL	UCLRL		LASL	UCLRL
Shot	B-57		Shot	B-57	
CACTUS	5		ASPEN		6
BUTTERNUT	6		LINDEN	4	
FIR		6	ELDER	5	
KOA	6		REDWOOD		5
WAHOO	2		HICKORY		4
HOLLY	4		OAK	6	
YELLOWWOOD	6		SEQUOIA	4	
NUTMEG		6	CEDAR		6
MAGNOLIA	4		DOGWOOD		6
TOBACCO	4		PISONIA	4	
SYCAMORE		6	POPLAR		5
ROSE	4		OLIVE		6
UMBRELLA	2		PINE		7
MAPLE		6	QUINCE		1
WALNUT	6		FIG		2

HARDTACK II

OTERO	1		RIO ARRIBA	3	
BERNALILLO	1		SOCORRO	4	
EDDY	5		WRANGELL		2
LUNA	1		OBERON		1
VALENCIA	1		RUSHMORE		2
MORA	4		CATRON	2	
HIDALGO	3		DE BACA	3	
COLFAX	1		SANFORD		3
QUAY	4		CHAVEZ	1	
LEA	4		SANTA FE	3	
HAMILTON		4	HUMBOLT		1
DONA ANA	3		BLANCA		1
KIWI A	4				
KIWI A PRIME	4				
KIWI A THREE	3				

GLOSSARY OF ABBREVIATIONS

-A-

AAF	Army Air Force
Acft.	Aircraft
Act.	Acting
AD	Air Division
ADC	Air Defense Command
Adj.	Adjutant
Adm.	Admiral
Admin	Administration
AEC	Atomic Energy Commission
AEDC	Arnold Engineering Development Center
AF	Air Force
AFAC	Air Force Armament Center
AFB	Air Force Base
AFCRC	Air Force Cambridge Research Center
AFTAC	Air Force Technical Applications Center
AFFTC	Air Force Flight Test Center
AFMDC	Air Force Missile Development Center
AFMTC	Air Force Missile Test Center
AFOAT	Office of the Assistant for Atomic Energy
AFR	Air Force Regulation
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project

AG	Adjutant General
ALOO	Albuquerque Operations Office
AMC	Air Materiel Command
APGC	Air Proving Ground Command
App.	Appendix
ARDC	Air Research and Development Command
Asst.	Assistant
ATC	Air Training Command
Attn.	Attention
Auth.	Authorized
Avn.	Aviation
AW	Atomic Warfare

-B-

BMD	Ballistic Missile Division
Brig.	Brigadier
BuAer	Bureau of Aeronautics

-C-

Capt.	Captain
CG	Commanding General
Chmn.	Chairman
CINCSAC	Commander in Chief, Strategic Air Command
Civ.	Civilian
Cmd.	Command

CNO	Chief of Naval Operations
Co.	Company
CO	Commanding Officer
CofS	Chief of Staff
Col.	Colonel
Comm.	Committee
Commun.	Communication (s)
Cong.	Congress(ional)
Corp.	Corporation
CTF	Commander, Task Force
CW	Chemical Warfare

-D-

DCG	Deputy Commanding General
D/Compt.	Deputy for Comptroller
DCS	Deputy Chief of Staff
DCS/C	Deputy Chief of Staff, Comptroller
DCS/D	Deputy Chief of Staff, Development
DCS/M	Deputy Chief of Staff, Materiel
DCS/O	Deputy Chief of Staff, Operations
DCS/P	Deputy Chief of Staff, Personnel
DCS/R&D	Deputy Chief of Staff, Research and Development

DD	Development Directorate
D/Dev.	Deputy for Development
Dep.	Deputy
Dev.	Development
DF	Disposition Form
Dir.	Director (ate)
Div.	Division
DMA	Division of Military Application
Doc.	Document
DOD	Department of Defense
D/Ops.	Deputy for Operations
DWET	Directorate of Weapons Effects Tests

-E-

Ed.	Editor
Eng.	Engineering
Engr.	Engineer
Eqp.	Equipment

-F-

FC/AFSWP	Field Command, Armed Forces Special Weapons Project
FEAF	Far Eastern Air Force
Ftr.	Fighter
FY	Fiscal Year

-G-

Gen.	General
GM	Guided Missile (s)
GO	General Order
Govt.	Government
Gp.	Group

-H-

Hist.	History, Historical, Historian
Hq.	Headquarters

-I-

IAS	Indicated Air Speed
IBDA	Indirect Bomb Damage Assessment
IFF	Identification, Friend or Foe
IG	Inspector General
Inc.	Incorporated
Incl.	Inclosure
Ind.	Indorsement
Info.	Information
Intel.	Intelligence
IP	Initial Point
ISAFB	Indian Springs Air Force Base

-J-

JCS	Joint Chiefs of Staff
Jt.	Joint
JTF (-7)	Joint Task Force (SEVEN)

-K-

KAFB	Kirtland Air Force Base
Kt.	Kiloton

-L-

Lab.	Laboratory
LABS	Low Altitude Bombing System
LASL	Los Alamos Scientific Laboratory
Lib.	Library
Ltr.	Letter

-M-

Maint.	Maintenance
Manp.	Manpower
Mat.	Materiel
Med.	Medical
Mgr.	Manager
Mgt.	Management
Mil.	Military
MIT	Massachusetts Institute of Technology
Mk	Mark

MLC	Military Liaison Committee
mm.	Millimeter
Mo.	Month(ly)
Mod.	Modification, Model
mph	Miles per hour
MSgt	Master Sergeant
Mt.	Megaton

-N-

NACA	National Advisory Committee for Aeronautics
NASWF	Naval Air Special Weapons Facility
n.d.	No date
NRDL	Naval Radiological Defense Laboratory
n.s.	No signature
n. subj.	No subject

-O-

Off.	Officer
OI	Office of Information
Op.(s)	Operation(s)
Org.	Organization

-P-

p. (pp)	Page(s)
Para.	Paragraph
Pers.	Personnel
Photo.	Photograph(ic)

Prep.	Prepared
Proj.	Project
Prov.	Provisional
Pub.	Publication(s)

-Q-

QM	Quartermaster
Quart.	Quarterly

-R-

RD	Restricted Data
R&D	Research and Development
RDB	Research and Development Board
Ref.	Reference
Reg.	Regulation
rpm	Revolutions per minute
Rpt.	Report
Rsch.	Research

-S-

SAC	Strategic Air Command
Sched.	Schedule
Sec.	Section
Secy.	Secretary
Sgt.	Sergeant
SO	Special Order
SOP	Standard Operating Procedure
Sq.	Squadron

Stat.	Statistic(al)
Subj.	Subject
Summ.	Summary
Sup.	Supply
Supp.	Support
Suppl.	Supplement
SWC	Special Weapons Command
SWBD	Special Weapons Development Board
SWOTO	Special Weapons Operations, Technical Operations
Sys.	System

-T-

TAC	Tactical Air Command
TDY	Temporary Duty
Tech.	Technical
Test Gp. (A)	Test Group (Atomic)
TG	Task Group
TN	Thermonuclear
Tng.	Training
TO	Technical Order
TWX	Teletypewriter Exchange Message

-U-

UCRL	University of California Lawrence Radiation Laboratories

UHF	Ultra High Frequency
USAF	United States Air Force
USAFE	United States Air Force in Europe
USAFIT	United States Air Force Institute of Technology
USMC	United States Marine Corps
USNOTS	United States Naval Ordnance Test Station

-V-

VHF	Very High Frequency
Vol.(s)	Volume(s)

-W-

WADC	Wright Air Development Center
Wkly.	Weekly
WPAFB	Wright-Patterson Air Force Base
Wpn.	Weapon
WW I	World War I
WW II	World War II

-Z-

ZI	Zone of Interior

DELETED

DELETED

AFWL/HO

GLOSSARY OF TERMS

DELETED

DELETED

adiabatic cooling	The process by which the temperature of an ascending body of air is changed by expansion, being about 1.6 degrees Fahrenheit for each 300 feet of change of height.
airburst	Strictly defined, the explosion of an atomic weapon in the air, above land or water, at a height greater than the maximum radius of the fireball.
alpha particle	Essentially the nucleus of the helium atom and consisting of two protons and two neutrons. Alpha emitting dusts, as associated with nuclear detonations, constitute a potential health hazard if inhaled or ingested.
ancillary equipment	That equipment designated for special operational or functional support of any part of a weapon.
arming system	That portion of a weapon which originates the signals required to arm, safe, or resafe the firing system and the fuzing system, and to actuate the nuclear safing system.
ballistic shape	1. An inert dummy weapon having the same external configuration and identical ballistic characteristics as the weapon with which it is associated. 2. The aerodynamic contour of a weapon.
baro	A pressure sensitive device used in some atomic bombs to actuate circuits. The term is a contraction of "barometric switch," sometimes referred to as "baro switch."

"beeper" pilot — Pilot operator of the radio equipment used to control drone aircraft. On testing missions, beeper pilot was aboard the "mother" planes, (or control aircraft).

beta particle — A form of radioactivity in which beta-particles are emitted from the radioactive body.

boosted weapon — A weapon to which some gaseous substance has been added such as deuterium, tritium, or lithium hydride to produce significant increase in fissioning and consequent increase in yield.

boosting — If a large supply of neutrons is suddenly injected into a system undergoing fission, while neutron multiplication is still occuring (before appreciable expansion has taken place), the total number of fissions and thus the efficiency and energy yield will be greatly increased. The first test of boosting was made in the ITEM Shot during Operation GREENHOUSE, 1951.

calorimeter — Apparatus for measuring quantities of heat.

Class A weapons (or Class B, C, or D) — A term commonly applied to one of the four general classes of thermonuclear weapons, specified by the Joint Chiefs of Staff, for development.

clean weapon — A weapon so designed that upon detonation the amount of contaminating material, in the form of either fission fragments or irradiated material (or both), is relatively low by comparison with other possible design variations of the same mark numbered weapon. A weapon may also be "clean" by comparison with different mark numbered weapons of the same general yield.

cloud tracking — The process of following the nuclear cloud with aircraft in order that sampling aircraft could move readily vectored into the cloud at the exact times required for obtaining the specific samples.

dirty weapon — A weapon so designed that upon detonation the amount of contaminating material, in the form of either fission fragments or irradiated material (or both), is relatively high by comparison with other possible design variations of the same mark numbered weapon. A weapon may also be "dirty" by comparison with different mark numbered weapons of the same general yield.

dose (dosage) — Ionizing radiation delivered to a specific area or volume or to the whole body. Units for dose specification are roentgens for X or gamma rays, roentgens equivalent man (rems) for alpha, beta and neutron bombardment of human tissue. In radiology the dose may be specified in air, on skin or at some depth beneath the surface; no statement of dose is complete without specification of location. In current thinking there is a tendency to regard a dose of radiation as the amount of energy absorbed by tissue at the site of interest per unit mass.

drag — That component of the total air forces on a body, in excess of the forces owing to ambient atmosphere and parallel to the relative gas stream but opposing the direction of motion; quantity which imposes limitations upon top speed of vehicles, missiles, and so forth.

drone aircraft — Radio-controlled aircraft not requiring the presence of crewmen aboard during flight.

drop sequence — The prescribed order of the events which take place in the arming, fuzing, and firing systems of an atomic weapon from time of release to detonation.

efficiency — The efficiency of an atomic weapon or device may be defined as the ratio of the energy actually developed when the bomb or device explodes (the energy yield) to the total energy available. In other words, efficiency is the fraction of energy available which is actually released in an explosion. In the case of a fission weapon this is equal to the ratio of the number of nuclei which actually undergo fission to the total number of fissionable nuclei present.

fallout — The precipitation to the earth of radioactive particles from the smoke and vapor produced by burst of an atomic weapon when the violence of the disturbance has subsided. After the detonation of a weapon, metallic oxide particles in the atomic cloud collide with particles of dirt (or with droplets of water as well as material from the bottom) up in the rising column. These particles or droplets become contaminated with radioactivity and they gradually fall back to earth, sometimes after having been carried considerable distances downwind.

film badge — Radioactivity sensitive device worn to indicate amount of radiation received.

fireball — The luminous sphere of hot gases which form a few millionths of a second after detonation of an atomic weapon and immediately starts expanding and cooling. In a nominal atomic bomb explosion, the ball of fire reaches a maximum radius of about 450 feet.

firing system — 1. For an implosion weapon, that portion of the weapon which, upon signal from the arming system, transforms and stores electrical energy, and, upon signal from the fuzing system, discharges this stored electrical energy to detonate the implosion system. This firing system will normally consist of the firing set, firing switch, load coils, load plates, detonator cables, other connecting cables, and structure.
2. For gun-assembly weapons, that portion of the weapon which receives a signal to ignite a pyrotechnic powder train, which in turn ignites the propellant.

fission — Although fission of heavy nuclei can be brought about in a number of ways, there is only one that is of importance for the practical release of nuclear energy: This is the fission initiated by neutrons. The reason is that the fission process is itself accompanied by the liberation of neutrons, so that a chain reaction with the continuous release of energy is possible. Three of the isotopes which can be used in a fission chain process are Uranium-233, Uranium-235, and

fisson (cont'd)	Plutonium-239. Although these substances are radioactive, they have relatively long half-lives, so that they may be regarded as moderately stable. Also, they will undergo fusion by the capture of neutrons of all energies-either fast (high energy) or slow (low energy).
fractionation	The breaking down of nuclear particles or of radioactive debris into various chemicals. Such breakdown increases difficulties of identification through radio-chemical analysis.
fusion	A nuclear reaction in which light nuclei combine to form a nucleus of a higher mass number. This process can be said to represent the opposite to nuclear fission. The fusion of nuclei of a low atomic number releases large amounts of energy. Such fusion reactions go on constantly in the interiors of stars and form the basic principle of the thermonuclear bomb.
fuzing system	That portion of a weapon which originates the signal which triggers the firing system. The fuzing system normally consists of such components as radars, baro switches, timers, impact crystals, antennas, baro sensing elements, and the like.
G or G-force	Force exerted upon an object by gravity or by reaction to acceleration or deceleration, as in a change of direction; one G is the measure of the gravitational pull required to move a body at the rate of about 32.16 feet per second.
gamma ray	Short wavelength electromagnetic radiation originating in the nucleus of certain radioactive atoms. The rays possess great penetration capabilities and, as associated with nuclear detonations, constitute a potential health hazard.
guided missile	A trajectile that is directed to its target while in flight or motion, either by a preset or self-reacting device within the trajectile or by radio command outside the missile.

gun-type weapon	These weapons consist essentially of a propellant charge which drives a projectile of fissionable material on to a fissionable target so that the combination becomes supercritical.
gust loading	The loading on aircraft in flight associated with the dynamic pressure in an air shock wave.
handling equipment	Special equipment used to handle, transport, or hoist special weapons components, major assemblies, or complete weapons; often included in lists of test and handling equipment as H-equipment.
implosion-type weapons	The type of atomic weapons in which a subcritical configuration of fissionable material is compressed into a supercritical state by a centrally directed radial shock, to produce an atomic explosion.
in-flight control and monitor equipment	Electrical equipment which provides the means of performing certain weapon or missile functions in flight, and monitors an atomic weapon to provide a simple go-no-go indication of weapon condition.
in-flight insertion	The process of inserting a nuclear capsule into the pit of an atomic warhead while it is airborne.
ionization	The process or result of any process by which a neutral atom or molecule acquires a positive or negative charge.
Joint Task Force (JTF)	A combined force of personnel of the Army, Navy, Air Force, and the Atomic Energy Commission, charged with conducting atomic tests. The commander is an officer of general or flag rank designated by the service acting as executive agency of the Joint Chiefs of Staff.
Joint Task Group (JTG)	A subsection of the Joint Task Force. Examples are: JTG-1 (Scientific), JTG-2 (Army), JTG-3 (Navy), and JTG-4 (Air Force).

kiloton	The accepted energy equivalent for 1,000 tons of TNT(trinitrotoluene). A nominal atomic bomb, similar to those dropped over Hiroshima and Nagasaki, has a TNT equivalent of 20 kilotons, or 20,000 tons.

DELETED

DELETED

Manhattan Project	The sum total of all activity which resulted in successful development of the Atomic Bomb.
mark-mod-alt	An abbreviation for mark-modification-alteration, the basic system of the Atomic Energy Commission for nomenclature of major assemblies of atomic weapons, which indicates the over-all design of a major assembly and changes thereto.
marriage program	The development effort conducted for the purpose of fitting atomic warheads to guided missiles or special weapons to aircraft.
megaton	The accepted energy equivalent for 1,000,000 tons of TNT.
Moratorium	A temporary ban on nuclear testing which resulted from international negotiations and which began in the United States on 31 Oct. 1958.
nuclear-cloud	The cloud phenomena which results from a a specific nuclear detonation as differentiated from atomspheric clouds. Radioactive material which may or may not have resulted from one specific nuclear detonation. Early nuclear cloud sampling was concerned with the visually recognizable cloud caused by a specific detonation; later world-wide sampling was conducted in specific atmospheric regions without regard to any specific cloud formations.

nuclear efficiency	The ratio (expressed as a percentage) between the number of atoms that fission and the total number of fissionable atoms available in a specific atomic weapon.
nuclear safing system	The portion of an atomic weapon that contains integrally all the apparatus which, on receipt of proper signals from the arming system, or by manual operation, functions so as to place the nuclear system in an armed or "safed" condition.
overpressure	The transient pressure, usually expressed in pounds-per-square-inch, exceeding atmospheric pressure, manifested in the blast wave from the explosion. The exact distribution is a function of time and of the weapon yield and the medium in which the weapon is detonated.
plasma physics	The science of dealing with the study of fully ionized gases.
predetonation	1. The premature explosion of the high explosive charge in an atomic weapon of the implosion-type, or of the propellant in an atomic weapon of the gun-type, before the weapon has reached the predesignated point of burst in its trajectory. 2. The premature commencement of fission of the active material in an atomic weapon before the designed criticality is achieved.
preinitiation	The premature commencement of fission of the active material in an atomic weapon before the designed criticality is achieved.
Rad-Safe Program (Radiological Safety)	The prescribed (by AEC) system of insuring safe control of radioactivity received by personnel; included handling, decontamination, pilot and crew exposure.
radiac	Radioactive. When used in connection with "instruments" or "detector," indicates device to measure and/or record radiation exposure.
roentgen	The quantity of X or gamma radiation such that the associated corpuscular emission per 0.001293 grams of air produces, in air, ions carrying one electrostatic unit of electricity of either sign.

salted nuclear weapon — A nuclear weapon which is designed such that a significant portion of the radioactivity of the particulate debris produced by its detonation results from the neutron activation of selected isotopes, deliberately introduced into the weapon for this purpose.

sample cave — Shielded v-shaped apparatus for rolling hot filter paper before inserting rolled papers into carrying cases (pigs).

sample collection — Various methods of atomic cloud sample collection have been tried at one time or another; the most satisfactory results have been obtained either by the use of drone aircraft guided through the atomic cloud or by means of manned aircraft. The samples collected are of two types; snap samples in which a container is filled with essentially gaseous material, and particulate samples obtained by drawing the air and other gases through a filter.

sampling mission — The combination of specific tasks required to obtain and prepare for shipment the exact types of samples required by various Federal agencies.

sampling pig — A thick-walled container, usually of lead, used to ship or store radioactive materials. The container protects the person handling the active material from radiation.

DELETED

DELETED

shielding — 1. Material of suitable thickness and physical characteristics used to protect personnel from radiation during the manufacture, handling, and transportation

shielding (cont'd)	of fissionable and radioactive materials. 2. Obstructions which tend to protect personnel or materials from the effects of an atomic explosion.
shock wave	The continuously propagated pressure pulse formed by the blast from an explosion -- in air by the air blast, underwater by the water blast, and underground by the earth blast. It is a pressure wave in the surrounding medium initiated by the expansion of the hot gases produced after the explosion. There are two phases to the shock wave: the positive and negative. During the positive phase the pressure rises abruptly to a pressure usually considerably higher than normal atmospheric pressure, and then declines rapidly. The duration of the positive phase is usually about half that of the subsequent negative phase. During the negative phase, the ambient pressure is reduced below atmospheric pressure.
stockpile-to-target sequence	The order and permutations of events involved in removing an atomic weapon from storage and assembling, testing, transporting, and delivering it to the target.
TACAN	Tactical air control and navigation system capable of presenting positioning information to the pilot within one degree of accuracy in azimuth and one per cent accuracy in range.
thermonuclear	An adjective referring to the process involving the fusion of light nuclei such as those of deuterium and tritium.
toroidal circulation	The circulation in the atomic fireball develops a doughnut-shaped form, with an updraft in the middle and a downdraft around the outside.
TX	A generic prefix to the number which designates the specific developmental model of a new atomic weapon. When the weapon reaches the production stage the TX designation is changed to a Mark or MK prefix.

warhead, implosion	That part of a missile warhead installation which includes the nuclear components, sphere case, high explosive system, detonators, detonator cables, firing element, firing switch, internal electrical circuits, in-flight insertion mechanism (if any), tritium gasboosting system (if any), and whatever hardware required to hold these parts together.
warhead installation	A missile warhead plus its adaption kit.
XW	A generic prefix designating a specific experimental model of an atomic warhead.

INDEX

-A-

A3C aircraft, 269
A4D aircraft, 165, 166, 179
ABLE Shot (CROSSROADS), 8-10
ABLE Shot (TUMBLER), 54
AFOAT-1, Operation BUSTER/JANGLE, 39, 42, 44; Operation CASTLE, 97; Operation PLUMBBOB, 167-168; Operation RANGER, 33; Operation REDWING, 270; sampling Operation UPSHOT/KNOTHOLE, 80; sampling responsibilities, 212, 261; sampling techniques, 76
Air Defense Command, 100, 154
Air Force Cambridge Research Center, 133-134, 145, 179, 269
Air Force Flight Test Center, 242
Air Force Special Weapons Center, 21, 53n, 80, 122n, 172, 232, 263n; approved sampling squadron, 263; flying safety award, 272; procuring suitable samplers, 124, 199, 242-243, 245-247, 249,251-253, 290; radiation exposure problems, 126-128, 130; sampling responsibilities, 212; sampling squadron transferred to MATS, 292; support to operations, 54, 83, 84, 94, 96, 99, 100, 112, 121, 130, 132, 152, 158, 167, 174-176, 179, 266
Air Force Technical Applications Center, 280, 283-285, 290, 292
Air Materiel Command, modifies aircraft for sampling, 65, 97, 99, 255; supports sampling, 6, 14, 34, 40, 280
Air National Guard, 167
Air Proving Ground Command, supports sampling, 14, 35, 40, 50-51
Air Research and Development Command, orders sampling squadron established, 266; sampling projects, 21, 50, 83n, 100, 175, 177, 245, 248, 251-252, 255, 263, 263n, 279; world-wide sampling, 280
Air Transport Command, 14
Air Weather Service, 24, 30, 37, 38, 261; sampling squadron a part of, 293-294; world-wide sampling projects, 280, 283, 285, 292
Alamogordo, N.M., 1, 4
Alaskan Air Command, 280, 284
Albuquerque, N. M., 4, 51, 128
Albuquerque Operations Office, 236
Aleutian Islands, 281
Andersen Air Force Base, 281, 287
Andrews Air Force Base, 134, 136
ANNIE Shot, 86
APACHE Shot, 149
APPLE Shot, 122, 126
Armed Forces Special Weapons Project, 48, 130, 133, 174, 246
Army Air Forces, Operation CROSSROADS, 3-4
Army Chemical Center, 76
Army, U. S., Operation CROSSROADS, 3; Operation SANDSTONE, 14
Atomic Energy Commission, 14, 42, 47, 163; accepts manned sampling, 38; radiation exposure problems, 81, 85, 90, 199-200, 236, 239; sampling requirements, 30, 33, 40, 42, 50, 97, 121, 158, 175, 242, 253, 265, 284, 290, 292; sampling techniques, 17-18, 20, 154, 222

-B-

B-17 aircraft, 41; in sampling, 6-13, 15-23, 34-37
B-25 aircraft, 165-166, 242
B-29 aircraft, 1, 9, 15, 209, 261; as controller aircraft, 67, 69-71, 73, 215; disadvantages as sampler, 47, 242; Operation BUSTER/JANGLE, 38-42, 44-46; Operation PLUMBBOB, 165; Operation TUMBLER/SNAPPER, 50-54, 56; Operation UPSHOT/KNOTHOLE, 82, 89
B-36 aircraft, as controller aircraft, Operation IVY, 67, 70-72, 77, 214; evaluation as sampler, 242; modified for sampling, 40, 98-99; Operation CASTLE, 97-98, 101, 106-107, 109, 111, 114, 117; Operation HARDTACK, 179; Operation REDWING, 141, 147-148, 270; Operation TEAPOT, 122-123, 132-134; proposed for IVY, 64; radiation exposure evaluated, 230
B-47 aircraft, 269, 288; Operation HARDTACK, 179; Operation PLUMBBOB, 166; proposed for thermonuclear sampling, 63-64, 77, 96, 242, 254; turned down for IVY, 64
B-50 aircraft, 32, 41, 49, 77; as sampler controller, 82, 84, 87, 90, 126; Operation PLUMBBOB, 165-166
B-52 aircraft, 147-148, 179, 245, 270
B-57 aircraft, 220; evaluation for sampling, 95, 117, 122, 126, 230, 242-244, 246, 294; modified for sampling, 40, 245; Operation HARDTACK, 176-179, 181-182, 189-192; Operation PLUMBBOB, 165-167, 172; Operation REDWING, 139, 141, 143, 145-149, 268; Operation TEAPOT, 123-124, 126; procuring the D-model for sampling, 246-256; radiation exposure, 225, 232-233, 236; special sampling projects, 274-276, 280, 284-288, 290-291
B-66 aircraft, 146, 269
BADGER Shot, 87, 89
BAIROKO, USS, 103
BAKER Shot (CROSSROADS), 10-13
BAKER Shot (TUMBLER), 54
Barksdale Air Force Base, 268

Batzel, Dr. Robert E., 96, 253
Bedford, Mass., 177
Bergstrom Air Force Base, 52, 65, 67, 77
Bickham, Capt. Claiborn F., 266-267
Bikini Atoll, Operation CASTLE, 109; Operation CROSSROADS, 9; Operation REDWING, 147, 149
BLACKFOOT Shot, 148
Blandy, VAdm. William H. P., 3
Blytheville Air Force Base, 269
Bounds, Maj. Malcolm S. 167, 255, 266
Box, Col. Clyde, 49
Bradbury, Dr. Norris E., 243, 251
Brandt, Maj. Gen. Carl A., 35
BRAVO Shot, 106, 239

350

Brown Field, Calif., 12
Bruce, Lieut. Lewis W., 266
Bunker, Brig. Gen. Howard G., 50
Burbank, Calif., 180
Bureau of Aeronautics, 154
Burke, Maj. Billy, 104
BUSTER ABLE Shot, 42, 44
BUSTER BAKER Shot, 44
BUSTER CHARLIE Shot, 45
BUSTER DOG Shot, 45
BUSTER EASY Shot, 45-46
BUSTER/JANGLE, Operation, 38-47; BUSTER ABLE Shot, 42, 44; BUSTER BAKER Shot, 44; BUSTER CHARLIE Shot, 45; BUSTER DOG Shot, 45; BUSTER EASY Shot, 45-46; JANGLE SUGAR Shot, 46; JANGLE UNCLE Shot, 46; planning, 39-41, 261; sampling the shots, 41-47; training for sampling, 263
Byars, Col. David O., Jr., 152
Bywater, Col. Murray A., 244

-C-

C-45 aircraft, 165-166
C-47 aircraft, 41, 109, 134, 165-166
C-54 aircraft, 41, 275-276
C-82 aircraft, 38, 261
C-97 aircraft, 145, 179, 269
C-119 aircraft, 165-166
C-124 aircraft, 182, 275
C-130 aircraft, 285-288
Camp Mercury, 85
Canterbury, Brig. Gen. William M., 152, 154, 248, 251-252, 254
Carney, Col. A. W., 253-255
Carrizozo, N.M., 2
CASTLE, Operation, 152, 277; BRAVO Shot, 106, 239; ECHO Shot, 111; KOON Shot, 109, 111; NECTAR Shot, 111; planning for, 93; ROMEO Shot, 106, 109; sampling aircraft, 97-103, 245; sampling requirements, 94-95, 245, 267; sampling shots, 103-117; sampling techniques, 222
Century Engineering Company, Inc., 40, 180
CHARLIE Shot (TUMBLER), 54, 72n
CHEROKEE Shot, 147, 252
Chula Vista, Calif., 12
Clovis Army Air Field, training at, 4-7
Cody, Col. Joseph J., Jr., Operation RANGER, 33-34, 37; Operation SANDSTONE, 21, 23-24; plans for manned sampling, 30-34, 261
Consta, Maj. Arthur L., 294
Corn, Maj. James T. 267
CREWCUT, Project, 277, 290
CROSSROADS, Operation, 3-13, 14-15, 20, 22; ABLE Shot, 8-10; BAKER Shot, 10-13; sampling, 4-13; Task Force One, 3
CROW FLIGHT, Project, 275, 288, 291
Crumley, Capt. Paul M., 127
Curry, Dr. Duncan, 245

-D-

DAKOTA Shot, 148
Day, MSgt. Jerome H., 48
Dean, Gordon, 265
Defense Atomic Support Agency, 292
Department of Defense, 48, 52, 55n, 159, 175

Division, 12th Air, 93

DOG Shot (GREENHOUSE), 36
DOG Shot (TUMBLER), 54
Donicht, Col. Harry L., 121
Drone samplers, 30, 117n; evaluation, 95-96; last used on large scale, 38; Operation CROSSROADS, 6-13; Operation GREENHOUSE, 34-37; Operation SANDSTONE, 15-23

-E-

Early, Charles W., 249
East Sale Air Base, 292
East Sale, Australia, 274, 281
EASY Shot (GREENHOUSE), 36-37
EASY Shot (SNAPPER 5), 55
ECHO Shot, 111
Edwards Air Force Base, 166
Eglin Air Force Base, supports sampling, 15-17, 35-36, 40, 46, 51
Eielson Air Force Base, Alaska, 281, 287
Ellingson, Capt., Quentin C., 266
Elmendorf, Maj. Harry E., 164, 248, 251
Eniwetok Atoll, 218, 267; Operation CASTLE, 100, 103, 106, 112; Operation CROSSROADS, 9, 11; Operation HARDTACK, 178, 182, 194; Operation IVY, 69, 72-75; Operation REDWING, 140, 147-149, 175; Operation SANDSTONE, 14, 18-20, 23; Proving Ground, 267
Ericson, Maj. Alan W., 161
ERIE Shot, 147

Estes, Brig. Gen. Howell M., Jr., on aircraft positioning during tests, 152-154; Operation CASTLE, 93, 93n, 96-97, 99, 102, 106-107, 109; procuring suitable samplers, 243-244; recommends B-57 for sampling 117
Estes, USS, 101-102

-F-

F6F-3K aircraft, 12-13
F6F5 aircraft, 12-13
F-84 aircraft, accident during MIKE Shot, 72-75; approved for Operation IVY, 50, 52, 65; contamination, 232, 236; evaluation for sampling, 94-96, 117, 139, 210, 230, 242-244; modified for sampling, 40, 80, 83, 97-98, 216-219, 243, 265; Operation CASTLE, 97, 99-102, 106-107,

109, 111-112, 222: Operation HARDTACK, 179, 255; Operation IVY, 66-67, 69-71, 75-77; Operation PLUMBBOB, 165-167, 172; Operation REDWING, 141, 147-149, 268-269; Operation TEAPOT, 122-123, 126, 134; Operation UPSHOT/KNOTHOLE, 81-82, 84, 87, 89-90; sampling trials in TUMBLER/SNAPPER, 54-56
F-86 aircraft, 126
F-89 aircraft, 47, 49, 64, 165, 166
F-94 aircraft, 47, 49-50, 64
F-101 aircraft, 269
FAT MAN, 1-2
Fackenthall, Lt. Col. Warren B., 161
Fackler, Col. Paul H., evaluates sampling aircraft, 47; permanent sampling unit, 265; Operation BUSTER/JANGLE, 38, 41, 44-45; Operation CASTLE, 104; Operation RANGER, 33-34, 37; Operation SANDSTONE, 21-23; Operation TEAPOT, 121n; Operation TUMBLER/SNAPPER, 48-49, 53 Operation UPSHOT/KNOTHOLE, 81, 84, 89-90; plans for manned sampling, 30-34, 38, 121, 261, 261n, 263, 263n; radiation exposure problems, 87, 90
Faktorow, Capt. Saul, 266
Felt, Dr. Gaelen L., 174, 253, 254
Fermi, Enrico, 2
Ferriss, Maj. Lester R., Jr., 31
FJ4 aircraft, 164, 166, 179
FLATHEAD Shot, 148
Flemming, Dr. Edward, 190
Fort Worth, Tex., 14
FOX Shot (SNAPPER 6), 55

-G-

Ganyard, Maj., Max B., 161
Gavin, Col. Edward M., 93, 96, 99, 244
Gent, Col. Thomas J., 35-36
George Air Force Base, 166
GEORGE Shot (GREENHOUSE), 37
GEORGE Shot (SNAPPER 7), 55
Glantzberg, Brig. Gen. Frederic E. commander, TG 132.4, 63; procures sampling aircraft, 65, 77
Glenn L. Martin Company, 40, 249-250, 255-256
GOLF BALL, Project, 277
Gordon, Capt. A. B., 212
GRABLE Shot, 89
Graves, Dr. Alvin C., 53; procuring sampling aircraft, 48-50, 82, 243, 246-248, 250-252, 254; proposals for sampling, 39, 237, 263-264; sampling description, 215-219; test director, 39
GREENHOUSE, Operation, 29, 95; DOG Shot, 36; EASY Shot, 36-37; GEORGE Shot, 37; guided missile sampling, 95, 180; ITEM Shot, 37; last of drone sampling, 38; manned sampling perfected, 229; planning, 34-35
Griffith, Gen. Perry B., 174-175

353

Group, 9th Weather Reconnaissance, 293-294
Group, 345 Bombardment, 269
Group, 405th Bombardment, 269
Group, 461st Bombardment, 269
Group, 509th Composite, 4
Group, 4900th Air Base, 163
Group, 4925th Test, (Atomic), 121, 132, 133; assigned sampling squadron, 266-267; procuring sampling aircraft, 50; support to operations, 270; support to sampling, 39-41, 48, 80, 104, 141, 277; training sampling crews, 50-52, 264; two-base sampling operations, 82
Group, 4950th Test, (Nuclear), 38n, 139; decontamination techniques, 236; established, 158, 261n; GOLF BALL, 292; mission and sampling, 158-159; Operation HARDTACK, 180; Operation PLUMBBOB, 159-161, 164-165, 168; procuring samplers, 253-255
Group, Experimental Guided Missiles, 15
Guam, 22, 179, 281, 285, 287
Guthals, Paul W., sampling evaluation, 191-192, 273; suitable sampling pilots, 213

-H-

H-19B helicopter, 151
H-21 helicopter, 165-166
Hall, Col. Harvey P., 294
Hamilton Field, Calif., 7

Hanlon, RAdm. Byron Hall, 174, 253-254
HARDTACK, Operation, 212n, 277; list of shots, 182-185, 186-189; Operation NEWSREEL, 186, 191; ORANGE Shot, 177, 186; planning, 174-182, 231-232, 254-256; sampling the shots Phase I, 182-186, 271; sampling the shots Phase II, 186-191; sampling requirements, 176; SANFORD Shot, 190; [redacted] TEAK Shot, 177, 186; TITANIA Shot, 189; YUCCA Shot, 177, 182
HARRY Shot, 89

Herry, Capt. Calo, 256
Hertford, K. F., 236
Hickam Air Force Base, Hawaii, 41, 193, 275
Hickam Field, Hawaii, 7
Hiroshima, Japan, 3
Hirschfielder, J. O., 1-2
Holtner, Brig. Gen. J. Stanley, 242
Holzman, Col. Benjamin G., 21
HONEST JOHN, 277
Hooks, Col. Daniel E., 49-50, 80, 263, 265
Houghton, Col. Karl H., 21, 39, 39n, 44 participates in sampling, 104, 112, 114; permanent sampling squadron, 265; radiation exposure problems, 81, 87, 90, 229, 232-233, 239

HOW Shot (SNAPPER 8), 55
Hull, Lt. Gen. John E., 14
Hunter, Col. William A., 255
HURON Shot, 149
Hynes, Lt. Col. Richard J., 139, 161, 254

-I-

INCA Shot, 148
Indian Springs Air Force Base, Operation HARDTACK Phase II, 186; Operation PLUMBBOB, 159-161, 163-165, 167, 172; Operation TEAPOT, 123, 127, 134; Operation UPSHOT/KNOTHOLE, 84, 87, 89; sampling activities, 32, 40, 54-55, 66-67; two-base sampling operations, 53, 82-83, 167
Isbell, Col. Robert N., 21
ITEM Shot, 37
IVY, Operation, 50, 52, 77, 80, 82, 93-95, 100, 102; preparation for sampling, 48, 63-66, 265; radiation problems, 76; sampling KING Shot, 75; sampling MIKE Shot, 69-74, 214-215; training programs, 66-69

-J-

Jacksonville, Fla., 189
JAGUAR, Project, 277
JANGLE SUGAR Shot, 46
JANGLE UNCLE Shot, 46
JB-57 samplers, 292

Johnston Island, 7, 186
Joint Task Force SEVEN, 93-94, 96, 99, 103, 152, 154, 174-175, 244, 253, 256

-K-

Kelley, Lieut. Robert L. 255
Kepner, Maj. Gen. William E., air commander for CROSSROADS, 3 for SANDSTONE, 14, 18, 19
Kesling, Col. Earl W., 39, 48, 245
KICKAPOO Shot, 148
Kieffer, Col. William B., 231-232, 236-237, 239
Kilgore, Col. John R., 15, 16, 18
KING Shot, 75
Kirtland Air Force Base, 40, 44, 54, 126, 269; radiation safety, 159; receives MATS sampling squadron as tenant, 295; sampling activities, 32, 40, 51-52, 143, 180, 182, 261, 275, 284, 293; sampling training programs, 66, 81-82, 102; support of operations, 122, 160-161, 163, 166, 178-179, 186; two-base sampling operation, 41, 53, 83, 172, 272
KIWI, Project, 273, 277, 288-290
Knoxville, Tenn., 134
KOON Shot, 109, 111
Kregloh, Capt. Edwin R., 40

Kwajalein Atoll, facilities for sampling, 64, 69, 76; Operation CROSSROADS, 7, 9; Operation IVY, 71, 75; Operation SANDSTONE, 18, 19

-L-

L-20 aircraft, 165
LACROSSE Shot, 147
Ladd, Maj. Roy E. 41
Landon, Col. Kurt M., 84
Langley Air Force Base, 269
Las Vegas Bombing Range, 29
Las Vegas, Nev., 29, 42, 44, 128
Laughlin Air Force Base, 181, 276, 281, 286
Laurence G. Hanscom Field, 177
LeBaron, Robert, 265
Lee, Maj. Gen. Robert M., 35
LeMay, Gen. Curtis E., proposals for sampling aircraft, 64
LITTLE BOY, 1
Livermore, Calif., 96
Long Beach, Calif., 276
Los Alamos Scientific Laboratory, 63; aircraft modifications, 249-251; designs sampling tanks, 179-180, 244-245, 250; KIWI, 288; Operation BUSTER/JANGLE, 39, 42; Operation CASTLE, 94, 96; Operation CROSSROADS, 4, 13; Operation HARDTACK, 191-193; Operation IVY, 64; Operation REDWING, 139-140; Operation SANDSTONE, 13, 20-22, 24; Operation TRINITY, 1; Operation TUMBLER/SNAPPER, 48-49, 52, 54; Operation UPSHOT/KNOTHOLE, 80, 82, 84; radiation exposure, 199, 211, 231; sampling responsibilities, 212-213, 215-219, 225, 284; testing and sampling requirements, 29, 34, 38, 40, 63, 66, 83, 94, 106, 114, 139, 168, 182, 198, 242-243, 246-247, 263-264, 273-274, 290

Ludlam, Capt. Douglas G., Jr., 294

-M-

Mahon, Col. Herschel D., 152, 249
Manhattan Project, 1, 4, 11-13
March Air Force Base, 166
March Field, Calif., 4
Marshall Islands, 12
McClellan Air Force Base, 39, 182, 287, 293
McClellan Central Laboratory, 212
McGehee, Lieut. Sam D., 266

McQuown, Maj. Herbert W., 266
Meinke, Capt. Francis B., 266
Menza, Capt. Dominic E., 48

MET Shot, 123
MIKE Shot, 69-74, 93-94, 214-215
Military Air Transport Service, 175-176, 280; receives sampling squadron, 292
Military Liaison Committee, 265
Miller, Col. G. W., 122

Mills, Brig. Gen. John S., Operation CASTLE, 93, 106; Operation TUMBLER/SNAPPER, 48; permanent sampling unit, 261; procuring suitable samplers, 242, 245; supporting Operation BUSTER/JANGLE, 38-39
Mitchell, Maj. Finis A., 104, 267
Mobile Air Materiel Area, 65, 97
MOHAWK Shot, 148-149

Moore, Philip R., procuring suitable samplers, 179; sampling evaluations, 191, 193
MUSIC MAN, Project, 274, 277, 288, 291-292
Myrtle Beach, S. C., 134, 136

-N-

Nagasaki, Japan, 3
NANCY Shot, 87
Nashville, Tenn., 134
NAVAJO Shot, 149
Naval Air Special Weapons Facility, 176, 178, 269
Naval Air Station, Atlantic City, N.J., 12
Naval Radiological Defense Laboratory, 133, 235
Navy, U. S., 154; Operation CASTLE, 101; Operation CROSSROADS, 3, 11-13; Operation TEAPOT, 133
NB-57 aircraft, 291
NECTAR Shot, 111
Nellis Air Force Base, 31, 33, 42, 166
Nevada Proving Ground, 84, 134, 218
Nevada Test Site, 45, 47, 80, 158, 163, 167, 186, 273
Newman, Col. Fred H., 277, 279
Norfolk, Va., 12, 134
Nugent, Col. Richard S., 96

-O-

Ogden Air Materiel Area, 98
Ogle, Dr. William, 243
Oldfield, Capt. Charles S. 255
Omohundro, Col. T. T., 249
Operation; see individual operation by name
ORANGE Shot, 177, 186
OSAGE Shot, 148
Ousley, Col. Carl A., 64, 141, 161, 163, 268

-P-

P2V aircraft, 41, 146, 179, 269
Pacific Area Command, 280
Pacific Proving Ground, 29, 67, 93, 96-97, 99, 105, 252
Partridge, Gen. Earle E., 245
Perry Island, 106
Peterson, Brig. Gen. Normal L., 293-294
Philippine Islands, 281
PILGRIM, Operation, 231, 252
Pinson, Col. Ernest A., radiation exposure problems 235, 239; radiation exposure study, 230
Plank, Dr. Harold F., on sampling techniques, 219-255; participates in sampling, 42 70-71, 76, 84, 90, 104; permanent sampling squadron, 265; procuring sampling aircraft, 49, 63, 94-95, 100, 124, 126, 139-140, 247-251, 254; radiation exposure problems, 81, 87, 90, 102, 231-232, 237, 239; training programs, 66
PLUMBBOB, Operation, 277; aircraft, 165-166; list of shots, 169-170; planning, 161-165; role of 4950th Test Group, 158-161; sampling plans, 167-168, 236-237; sampling shots, 168-172, 272; SHASTA Shot, 171
Power, Lt. Gen. Thomas S., 251, 279
Price, Maj. Joseph L., 167

-Q-

Q-2 drone, 96
Quarles, Hon. Donald A., 279

-R-

Raleigh, N. C., 134
Ramey, Brig. Gen. Roger M., commanding sampling efforts for CROSSROADS, 3, 4 for SANDSTONE, 14
RANGER, Operation, 29-34, 37; first manned sampling, 30, 33-34, 41, 229, 242; preparation for, 32
RAY Shot, 87
RB-36 aircraft, 102, 104, 107, 117
RB-52 aircraft, 269
RB-57 aircraft, 280
REDWING, Operation, 175, 277; APACHE Shot, 149; BLACKFOOT Shot, 148; CHEROKEE Shot, 146-147, 252, 260; DAKOTA Shot, 148; ERIE Shot, 147; FLATHEAD Shot, 148; flight safety, 151-152; HURON Shot, 149, INCA Shot, 148; KICKAPOO Shot, 148; LACROSSE Shot, 146; MOHAWK Shot, 148-149; NAVAJO Shot, 149; OSAGE Shot, 148, 270; planning, 139-141, 143, 145, 243, 249; radiation problems, 149-150, 232; sampling shots, 145-150; SEMINOLE Shot, 147-148; TEWA Shot, 149; YUMA Shot, 147; ZUNI Shot, 147

358

357

Reeves, James E., 253
Reid, Elliott, 40
Rendova, USS, 67, 69, 76
Richardson, Maj. Gen. William L., 15
Ritland, Col. Osmund J., 48, 80
Robbins, Lt. Col. Carl W., Jr., 161

Rockinham, USS, 7
ROMEO Shot, 106, 109
Rose, Capt. William S., 82
Rosemont, Calif., 180
Roswell Army Air Field, N.M., 4
Roswell, N.M., 4
ROVER, Project, 273, 277, 288
Rowan, Lieut. John M., 266
Royal Canadian Air Force, 272
Rubinson, William, 4-5, 13

-S-

SA-16 aircraft, 151
Sampling, cloud characteristics, 201-206; drones, 6-13, 15-23, 30, 36-38, 96, 117; first manned, 30, 33-34; fractionation discussed, 4-5; guided missiles, 95-96, 180, 243-244; pre-manned, 1-24; procuring suitable aircraft, 48-53, 122; radiation dosage, 67, 76, 81, 83, 85, 103, 127-128, 149-150, 180-181, 205-212, 229-239; techniques, 13, 17-20, 51, 76, 85, 104, 114, 180-181, 193-194, 198-199, 212-226

Samuel, Col. John S., 143, 145, 151, 252
San Antonio Air Materiel Area, 98
San Diego, Calif., 12, 67, 180
San Diego Naval Air Station, 101
SANDSTONE, Operation, 13-24, 29-30, 34; Rad-Safe program, 21, 238; sampling, 15-23; X RAY Shot, 19-20; YOKE Shot, 20; ZEBRA Shot, 21
SANFORD Shot, 190

Schwartz, Samuel, 133
Scott Air Force Base, 293
SEMINOLE Shot, 147-148
Sewell, Dr. Duane C., 243
Shangri-La, USS, 12
SHASTA Shot, 171
Shipman, Dr. T. L., 238
Shot; see individual shot by name
[redacted]
Solar Aircraft Company, 40, 180
Special Weapons Command, 38-39, 53n, 263n; support to IVY planning, 64; support to Operation TUMBLER/SNAPPER, 47-50, 53; TG 132.4 established, 63

Spence, Dr. R. W., 247-248
Squadron, 57th Reconnaissance, 40
Squadron, 393rd Bombardment, 4
Squadron, 1211th Test, (Sampling), mission, 293; new home, 293; tenant at Kirtland AFB, 294; see also Squadron, 4926th Test, (Sampling)
Squadron, 3200th Drone, 35
Squadron, 4926th Test, (Sampling), Air Force Outstanding Unit Award, 277, 279; established, 261, 266-267; flight safety maneuvers, 151-152, 239; flying safety award, 272; GOLF BALL, 292; KIWI, 288-290; MUSIC MAN, 291-292; Operation CASTLE, 99-102, 106; Operation HARDTACK, 179, 181, 190, 271; Operation PLUMBBOB, 167, 171-172, 272; Operation REDWING, 139-141, 143; Operation TEAPOT, 126, 134, 136; procuring suitable samplers, 122, 139, 177, 180, 256; radiation safety, 150, 230; sampling responsibilities, 212, 270, 273-274; special sampling projects, 276-277; SUNDAY PUNCH, 290-291; Test Aircraft Unit, 267-279; transferred to MATS, 292-294 (change-of-command, 293-294); under 4950th, 158, 161; world-wide sampling projects, 280-288
Squadron, 4928th Test, 270
Squadron, 4935th Air Base, 159-160, 164, 273
Squadron, 4952nd Support, 159-160
Stewart, Col. C. B., 246
Stockman, Capt. Harvey S., 82
Stanford University, 40
Starkey, Lt. Col. James S., 84
Stranathan, Maj. Gen. L. S., 246-247
Strategic Air Command, 64; Operation CASTLE, 93, 100; Operation REDWING, 143, 153, 268-269; participation in SANDSTONE, 14; pilots and aircraft in IVY, 66, 67; support to Operation HARDTACK, 176-177, 179, 181, 254-256; support to TUMBLER/SNAPPER, 52, 54; support to UPSHOT/KNOTHOLE, 82; training sampler pilots, 272; world-wide sampling projects, 275, 280, 282-284, 291
Sheet, Kenneth, 96
SUNDAY PUNCH, Project, 277, 290-291

-T-

T-33 aircraft, evaluation as sampler, 47, 126, 230, 242, 246; used for sampling, 35-36, 40, 44-46, 50-56, 165-166; used for sampling training, 80
Tactical Air Command, 139, 143, 145
Task Force ONE, 3
Task Force SEVEN, organized, 14
Task Force 132, 93
Task Group 1.5 (Provisional), 4
Task Group 132.4, 56; formed, 52, 63; planning for CASTLE, 94; preparation for IVY, 64-65, 76-77, 265
Task Group 3.4, 35
Task Group 7.1, 152, 174, 253

Task Group 7.4, Operation CASTLE, 97, 100, 103, 106, 111; Operation HARDTACK, 175-178, 195; Operation REDWING, 139-141, 146n, 150, 152; organization of, 14-15; radiation safety training, 181; sampling techniques used, 219-225; suitable samplers, 252
TEAK Shot, 177, 186
TEAPOT, Operation, 277; APPLE Shot, 122, 126; HIGH ALTITUDE Shot, 130, 132-134, 136; HORNET Shot, 126; MET Shot, 123; planning, 121; radiation problems, 232; sampling highlights, 122-130; sampling preparations, 121-122; WASP-PRIME Shot, 126
TEWA Shot, 149
TF-80 aircraft, 35
Thompson, Col. Alden G., 161
TIGER/CAT, Operation, 100, 277
TITANIA Shot, 189
Tracerlab, Incorporated, 40, 98
Travis Air Force Base, 275-276
TRINITY, Operation, 1-2, 29
Truman, Pres. Harry S., 3, 14
TRUMPET, Operation, 212, ~~212n~~, 231-232
TUMBLER/SNAPPER, Operation, 47-56, 66, 72n, 80; sampling shots, 53-56; suitable sampling aircraft, 48-51; Test Aircraft Unit formed, 48; training for sampling, 263

-U-

U-2 aircraft, 255, 275, 282-284, 286-287
University of California Radiation Laboratory, 96-97, 140, 168, 182, 190, 212, 243, 253
UPSHOT/KNOTHOLE, Operation, 93, 267, 277; ANNIE Shot, 86; BADGER Shot, 87; HARRY Shot, 89; list of shots, 86; NANCY Shot, 87; RAY Shot, 87; sampling preparations, 80-84, 266; sampling the shots, 84-90

-W-

Waddleton, Col. Thomas R., 252
Walk, Brig. Gen., A. R., 96
Walker Air Force Base, 66
Walker, Lt. Col. Walter B., 161
Warner-Robins Air Materiel Area, 141, 143, 180
Washington, D. C., 38, 136, 139
WASP PRIME Shot, 126
Watkins, Lt. Col. James A., 82, 267
WB-29 aircraft, 22, 23; first used in manned sampling, 30, 33, 37
WB-50 aircraft, 242, 280, 285, 287
Wignall, Col. Paul R., 161, 168
Wilson, Maj. Gen. Roscoe E., 33, 38
Wing, 12th Fighter, 52
Wing, 58th, 4
Wing, 301st Bombardment, 268
Wing, 405th Bomb, 145

Wing, 461st Bomb, 145
Wing, 550th Guided Missiles, 35
Wing, 4080th Strategic Reconnaissance, (Light), 178, 256, 282, 290
Wing, 4901st Support, (Atomic), 54
World War II, 1, 267
Wright Air Development Center, 51, 65-66, 96-98, 161, 177, 179, 248, 269

Wright-Patterson Air Base, 6

-X-

X RAY Shot, 19-20, 22

-Y-

YANKEE Shot, 111
YOKE Shot, 20
Yokota Air Base, 286
Yokota, Japan, 281, 285
YUCCA Shot, 177, 182
YUMA Shot, 147

-Z-

ZEBRA Shot, 21, 22
ZUNI Shot, 147