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EXTRACTED VERSION

OPERATION PLUMBBOB

Report of Test Manager

December 1957

Nevada Test Site

May-October 1957

NOTICE

This is an extract of **Operation PLUMBBOB, Report of the Test Manager**, which remains classified **Secret/Restricted Data** as of this date.

Extract version prepared for:

Director

DEFENSE NUCLEAR AGENCY

Washington, D. C. 20305

1 February 1980

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FOREWARD

This report has had classified material removed in order to make the information available on an unclassified, open publication basis, to any interested parties. This effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NIPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

This report has been reproduced directly from available copies of the original material. The locations from which material has been deleted is generally obvious by the spacings and "holes" in the text. Thus, the context of the material deleted is identified to assist the reader in the determination of whether the deleted information is germane to his study.

FOREWARD

The Test Manager's report, was prepared under the supervision of the Director Nevada Operation Division, Office of Test Operations, Albuquerque Operations, Atomic Energy Commission, in coordination with cognizant government agencies and contractors of the AEC. It presents a summary of the 1957 nuclear weapons tests conducted at the Nevada Test Site, entitled ''Operation Plumbbob.'' Pre-operational planning involved the use of the code name ''Operation Pilgrim.'' This designation was changed to ''Operation Plumbbob.'' All references to ''Pilgrim'' therefore apply to ''Plumbbob.''

Preparation of the report has been guided by two objectives; first, that it may be utilized as a reference by those who are concerned with the planning, or authorization of the operation, and secondly, that it will serve as planning guide for future continental test operations.

The official ''Operation Plumbbob'' period, March 15, 1957, to October 12, 1957, is discussed from a logistical and management viewpoint only. Information relative to pre-operational planning is included to permit an understanding of the scope of operational and logistical problems. Scientific data associated with the phenomena of devices detonated during the series will be found in the various technical documents listed in the references to this report, or available from the participating agencies.

In general, major recommendations for improved organization or methodology have been summarized. Technical papers supporting recommendations are, in many instances, receiving further staff analysis and coordination. They will be considered in planning future on-continent nuclear weapons tests, or, if pertinent, be considered in the planning for weapons tests to be conducted at the Eniwetok Proving Ground.

James E. Reeves, Test Manager
Nevada Test Organization

ACKNOWLEDGMENT

The Office of Test Operations, Albuquerque Operations, Atomic Energy Commission, as the responsible preparing organization, has been ably assited in the preparation of this report by the submission of material developed by participants in the test series, representing the the University of California Radiation Laboratory, Los Alamos Scientific Laboratory, of the University of California; Sandia Corporation; Department of Defense; United States Public Health Service; Federal Civil Defense Administration; United States Air Force Air Weather Service; Civil Aeronauties Administration; United States Weather Bureau and AEC support contractors, Holmes & Narver, Inc., Reynolds Electrical & Engineering Company, Inc., and Edgerton-Germeshausen & Grier, Inc.

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PART III

SCIENTIFIC ACCOUNT

PART III

CHAPTER 1

OBJECTIVES

Purpose

1.1 Operation Plumbbob was designed to conduct experiments concerned with the advancement of the technical understanding of nuclear and thermonuclear weapons, to test prototypes and mockups of weapons, and to develop further information on military and civil effects, including studies of basic phenomenology of the explosion. In addition to the basic purpose of the operation, advantage was taken of detonations to provide training for military and civil effects groups under field conditions.

1.2 During the course of the operation test techniques were developed which permit greater flexibility in utilization of the Nevada Test Site, the two major steps being the use of captive balloons and the firing of a device underground.

1.3 The weapons development program was directed towards the following objectives:

To secure weapons of smaller size with a greater delivery capability.

To achieve a greater economy in the use of active materials.

To continue development of weapons with a high safety factor in handling, storage, and delivery.

To secure basic information on higher yield designs in devices and weapons which will later be tested in the Pacific.

Test Director's Comments

1.4 A major difficulty appeared in the beginning with users requesting a large number of dry runs. Many of these were eliminated in the course of the operation.

1.5 There were no major problems in housing or vehicles.

1.6 The basic organization that was established for the Plumbbob Operation is consistent with what all of the users desired. The major strength for accomplishment of the technical measurements should and did reside within the technical test groups. In some instances additional staff support was required and obtained.

1.7 The construction and support contractors met and in some cases exceeded schedules. In the case of towers the fact that they were ready, in some cases early, could not be taken full advantage of because of inflexibility in some test groups with respect to taking advantage of the improved situation.

1.8 Within the body of the Test Director's report are numerous, specific, detailed recommendations with respect to improving joint operations in Nevada.

CHAPTER 2

SUMMARY OF RESULTS

Advancements

2.1 During Plumbbob advancements were made in furthering all of the test objectives. In several systems successful tests produced data which permit the design of weapons with optimized investments in fuel.

.1 Five safety tests were conducted of weapons and devices. Some were discovered to be safe as built and for others adequate data were obtained for the design of safe systems.

Weapons Effects

2.2 The weapons effects program of the Department of Defense was directed primarily toward the study of blast and shock phenomena, and the response of structures in the overpressure region above 50 psi. In addition, information was collected on induced radioactivity, on electromagnetic signal generation by the detonation, and on the propagation of electromagnetic radiation in the ionized region surrounding a detonation. One shot fired in mountainous terrain lead to measurements of shock and blast effects under such conditions. An air-to-air delivery of a M-1 rocket with a nuclear warhead provided information on nuclear and blast inputs necessary to establish delivery criteria.

2.3 The principal effort in the study of strong shocks was expended on the Priscilla shot. Successful measurements were obtained for peak overpressures from 970 psi downward and for dynamic pressures from 280 psi downward. The first experimental confirmation was obtained of the expected sharp drop in dynamic pressure from the region of Mach to the region of regular reflection. Studies of precursor phenomena revealed that tower shielding may inhibit the formation of a precursor. Extensive measurements of earth shock induced by air blast and their effects were carried out. Measured values of accelerations agreed with prediction in the first ten feet but there were discrepancies in the next lower twenty feet, which may have resulted from anisotropies in the soil. Vertical earth displacements produced by the shock wave were measured and typical values observed were 14 inches at 270 psi and 2 inches at 60 psi.

2.4 Terrain effects were determined on the Smoky Event. The results may be summarized as follows:

2.4.1 Overpressures on front slopes are higher and on back slopes lower than for flat terrain at the same distances.

2.4.2 Overpressures on low, rolling terrain are higher than flat terrain pressures for like ground distances; dynamic pressures are lower.

2.4.3 Dynamic pressures on front slopes of high-ridges are lower than flat terrain pressures at corresponding distances and fall sharply below flat terrain pressures on back slopes.

2.4.4 The wave forms on all front slopes have a shorter rise time than the corresponding wave forms on the flat terrain line. Wave forms on back slopes are nearly ideal.

Nuclear Radiation Effects

2.5 The nuclear radiation effects measurements were successful, indicating that neutron

induced soil activity is a definite tactical hazard at early times. The primary isotopes which add to the radiation field are Na^{24}, Mn^{56}, and Al^{28}. The induced activity was observed to be primarily generated by thermal neutrons, but higher energy neutrons also contributed. The effect of increased moisture was to increase the intensity of the fields, although the effect is not as critical as had been expected.

2.6 Prompt neutron dosages were found to depend strongly on weapons design and valuable numerical results were obtained for several designs.

2.7 From the initial gamma radiation measurements, it was found that in the first five second interval after detonation, the total gamma radiation increased with altitude to 400 feet, where about 30% more was received than would have been on the surface for the same distance from the point of detonation.

Shielding

2.8 Measurements of shielding afforded by underground shelters yielded useful data on shielding factors in the main structures and entry ways.

Structures

2.9 The results of the structures program made significant contributions to understanding loading and response of surface and underground structures in the overpressure regions above 50 psi. Generally the underground structures tested sustained less damage than predicted, from which it was concluded that the design assumptions upon which the structures were constructed and analyzed were more conservative than necessary. It was shown that underground arch-type shelters are the most efficient type and can be readily constructed to withstand overpressures up to 200 psi. For above surface structures, arch or dome types can be designed to survive up to 70 psi.

Biomedical Program

2.10 The biomedical program succeeded in providing information on: (1) the effects of nuclear weapons on large animals (swine); (2) the eye protection provided by an electromechanical shutter; and (3) the casualty effects of missiles translated by a shock wave.

2.11 Under the experimental conditions involved in the mass casualty studies on a large number of pigs, animals suffering missile wounds from glass, in most instances, received lethal doses of radiation. Many of the animals received serious thermal burns. There was an inverse association between degree of burn and survival time of the exposed animals. Certain clearcut conclusions were reached; namely, for a large biological specimen in the open, within the precursor of a nuclear weapon, the primary cause of death is mechanical injury to the organisms due to translation and nearly 100% are killed instantly. Outside the precursor region, temporary survival may be expected in the open, but barring total missile injury, the radiation levels are lethal. Close-in foxholes may provide protection to prevent total injury from blast and burn, but lethal radiation dosages will also be received.

2.12 Preliminary results give an LD/50/30 of pigs to be about 500 rep gamma rays plus neutrons, which agrees well with laboratory results but disagrees with earlier field results.

2.13 The electromechanical shutter, with a response time of .5 millisecond gave complete protection from chorioretinal burns and flash blindness. A goggle can now be designed for service testing.

Aircraft Structures

2.14 Preliminary field analysis of data collected in the aircraft structures program indicate that the objectives of the various aircraft studies were successfully met except for the airship project, where further detailed analysis is required. Basic objectives were to determine safety delivery criteria for nuclear weapons.

Air-to-Air Missile

2.15 The delivery of the air-to-air missile

by an F89D gave information on thermal radiation, blast inputs and responses, and nuclear radiation. Data were obtained on effects of gust loads imposed on maneuvering loads. Measurements on other events were made with airships, HSS-1, F4H, and A4D-1 aircraft.

Mine Clearance

2.16 The results of a mine clearance study using a field of live and instrumented mines proved that the methods of prediction of mine actuation are reliable. In addition, details were obtained on the effects of depth of burial and of wave form of shock on actuation.

Electromagnetic Effects

2.17 The program to measure electromagnetic effects led to successful measurements of the azimuthal, radial, and vertical components of the magnetic field in the frequency region up to 200 kc. The strongest component was azimuthal and the field dropped by an order of magnitude in less than 100 microseconds.

Radio and Radar Signals

2.18 The investigation to measure the effects on propagation of radio and radar signals from an aircraft transmitter to ground receivers failed to show any attenuation at several frequencies from 4 mc up to 9200 mc. Radar tracking of an aircraft from H / 3 to H / 5 minutes through a nuclear cloud using X-band radar was successful.

Detection of Nuclear Detonations

2.19 A project involving long range detection and location of nuclear detonations over distances of several hundred miles gave fixes to within [redacted] From pulses observed from lightning transients it was found that no consistent patterns peculiar to wave forms, field intensities, or pulse durations of these transients could distinguish them from the electromagnetic pulse of a nuclear detonation.

Civil Effects

2.20 The civil effects program broke into six major categories: (1) studies of fallout, (2) biomedical and physical aspects of prompt gamma and neutron radiation; (3) blast effects on structures; (4) biomedical effects of blast; (5) radiological contamination, decontamination and training, and (6) instrumentation and supporting services.

Fallout

2.21 Estensive studies were made of fallout with emphasis on documentation of the fallout patterns and detailed analysis of the fallout material to determine its physical and chemical properties. Included were studies of changes in nature of fallout material with time, particle size distribution and the availability of the radioactive material to the biosphere. Measurements were obtained of shielding afforded by structures and nuclear distribution in air of bomb radiation was successfully accomplished. Ultimately it is hoped that these data will be effective in permitting the establishment of individual dosages received by Japanese survivors.

Civil Defense

2.22 The Federal Civil Defense structures program resulted in important measurements concerned with design of reinforced concrete dome shelters, a dual-purpose garage shelter, a family shelter, and an array of shelters designed by engineers in France and Germany. Also in the program were studies of doors, anti-blast valves for ventilating systems, and a modular brick building.

Biological Program

2.23 The biological program was concerned with the biological response to various patterns of overpressure, the effects of missiles, and the effects of physical displacement of of the biological target by blast produced

winds. Closely associated were measurements of blast inside open structures to provide data for design criteria for shelters not requiring doors.

Radiological Defense

2.24 A radiological defense experiment was conducted successfully in which a group from the Naval Radiological Defense Laboratory occupied a protective shelter in a region of heavy fallout. Methods of determining the magnitude of the radiation field and operations to leave the shelter and decontaminate a working area were effectively demonstrated.

Training

2.25 The FCDA sponsored a group of training exercises to provide experience in contaminated areas to radiological defense leaders selected from State and local civil defense organization.

Radiation Monitoring

2.26 A system of remote gamma radiation monitoring was carried out at stations at distances from 30 miles out to 300 miles. The system gave offsite radiation intensities resulting from fallout by simply dialing the station through the phone network which automatically replied giving the radiation level using a coded signal.

Fireball Phenomena

2.27 Sandia conducted an experiment (1) to continue the exploration of the effects of close-in fireball phenomena on basic materials; (2) to continue exploration of the effects of close-in fireball phenomena on weapon components; and (3) to gain further understanding of fireball physics.

Fuzing and Firing

2.28 Measurements were made of response of fuzing components, assemblies, complete in detail except for high explosive and nuclear materials. Magnetic tape systems recorded accelerations, pressures, and fuzing and firing functions

Material Studies

2.29 Basic material studies were made both for materials placed within the fireball in billets mounted on the tower and for material placed at various positions along the ground near the point of detonation.

Neutron and Gamma Radiation

2.30 Studies were made of early neutron and gamma radiation fluxes as a function of time, and also free field neutron flux measurements as a function of altitude to obtain the effects of terrain.

New Techniques

2.31 Two new test techniques were tried during the operation -- namely, the use of captive balloons and of firing underground. The captive balloon system was developed by Sandia prior to the operation and was successfully used throughout. The underground shot was fired near the end of the operation and was purely a test of the confinement design and of the measurement methods.

Balloon Experiments

2.32 The balloons were used to carry loads weighing from 1800 to 4400 lbs at altitudes of 500 feet to 1500 feet. Balloon positioning could be held to plus or minus 30 feet at a 1500 foot altitude in winds up to 20 miles per hour While the balloons flew repeatedly in winds of 35 to 45 miles per hour, it was decided for safety of personnel and handling case that they should not be used operationally in winds of speed greater than 20 miles per hour.

2.33 The balloon was raised and lowered by winches operated remotely from the control point. The position and behavior of the balloon, and the wind speed at balloon altitude were all monitored at the control point.

2.34 The use of balloons reduced the close in local fallout to values of a few percent of that for tower shots. As a consequence when winds were appropriate for balloon operation, there were no delays for fallout reasons.

2.35 The entire system was highly successful and, in fact, made possible the accomplishment of the Plumbbob program. The success is confirmed by noting that twelve of the twenty-four full scale nuclear detonations fired above the surface were fired from balloons.

Underground Experiment

2.36 The underground shot of 1.7 KT at a depth of 900 feet verified the calculations with respect to containment and instrumentation.

No detectable radioactivity was vented at any point. After the detonation the tunnel was reentered and it was possible to proceed on foot to within 200 feet of the center of the detonation. At this distance the tunnel was partially collapsed and full of broken rock, however, here also there was no detectable radioactivity. There were no offsite effects and the seismic signals could not be felt at a distance of 2.5 miles. The general feasibility of the method was proved and as a consequence plans are being developed for further underground tests.

Decontamination Problem

2.37 A new problem in decontamination was presented by the balloon operation. Generally, the balloons were fired, as planned, at altitudes such that the fission product fallout was small, however, in some cases the activity induced by neutron absorption in the soil was as high as several hundred R/hour at one hour. Since the balloon sites were required for repeated firings it was important to consider decontamination procedures. A major difference was apparent between such contamination and fission product fallout -- mainly that the neutrons were absorbed in a relatively thick layer so that earth removal methods would require the removal of one to two feet of soil, which would be an unusually operational requirement, as compared with only surface contamination from fallout. In some cases, an equivalent amount of unactivated earth was placed over the area to provide shielding, but here again a large amount of earth was required. To study methods of reducing this problem, an experiment using a boron-containing-mineral incorporated in the first two feet of soil was carried out with encouraging results.

Scientific Support

2.39 Edgerton, Germeshausen, and Grier, Inc. provided timing and firing, scientific photography, alpha and other radiation measurements.

Major tasks of the photographic unit was to measure fireball growth for yield, growth and motion of atomic cloud after shock breakaway, and position of burst for the air-to-air missile. Photographs were also made for DOD and CETG to determine effects of blast and thermal radiation on structures and materials.

2.40 Reaction history measurements were made by the EG&G alpha group for LASL. The measurements included neutron multiplication rate throughout the entire measurable history,

Improvements were made in the image converter streak camera which is smaller and more portable than cameras of this type used before.

Conclusion

2.41 Overall the major objectives were accomplished by all participating test groups.

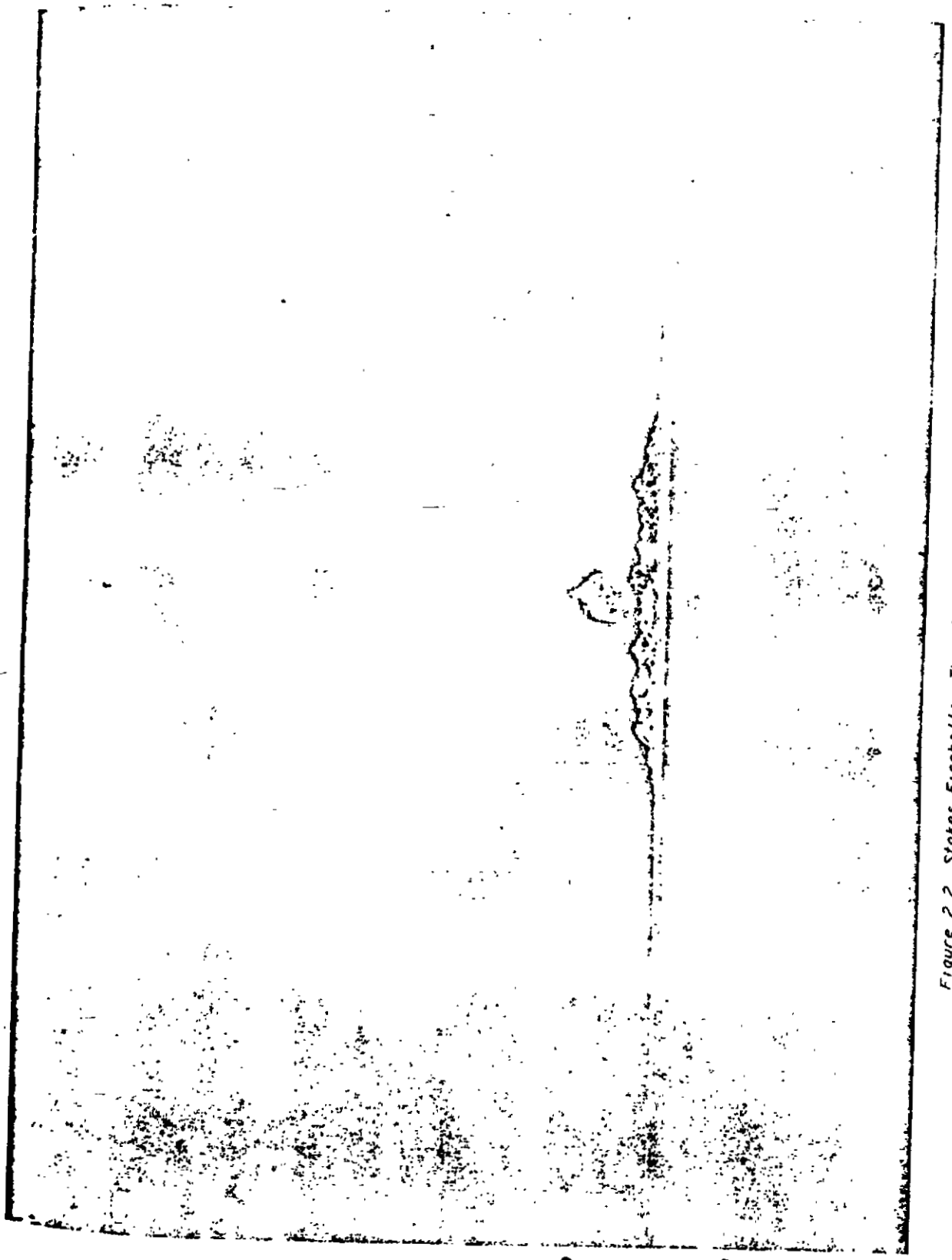

Figure 2 2 Stokes Fireball: The eleventh nuclear detonation of the Plumbbob series lights Yucca Flat at 5:25 a.m., Wednesday, August 7, 1957 Stokes was fired from a balloon at an altitude of 1500 feet

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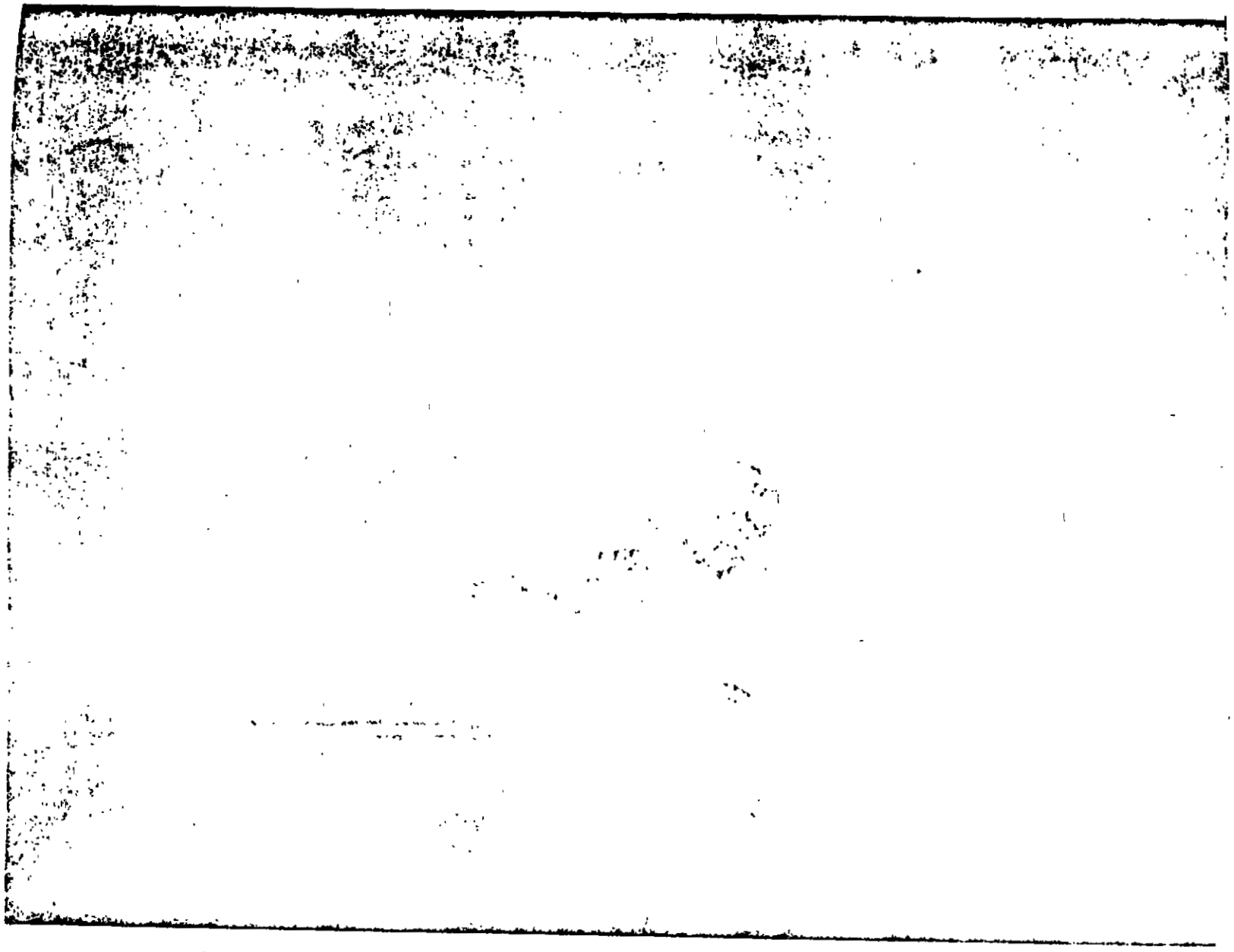

Figure 2.4 Fireball of Kepler, the ninth atomic detonation of Operation Plumbbob, flashes across Yucca Flat at 4:50 a.m. PDT, Wednesday, July 24, 1957

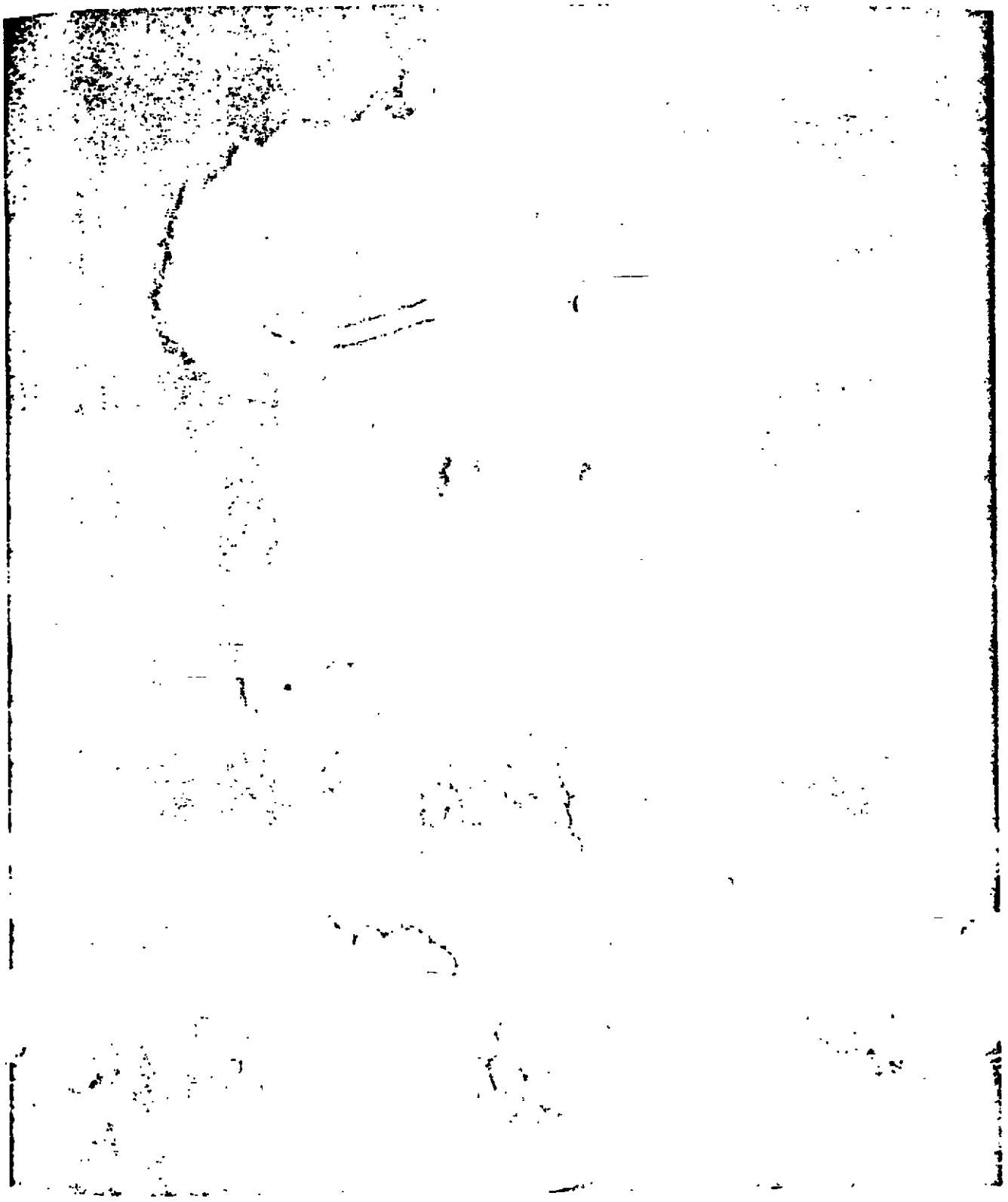

Figure 2.7 The fireball of Priscilla, the fifth shot, Summer 1957 series, rises from Frenchman Flat

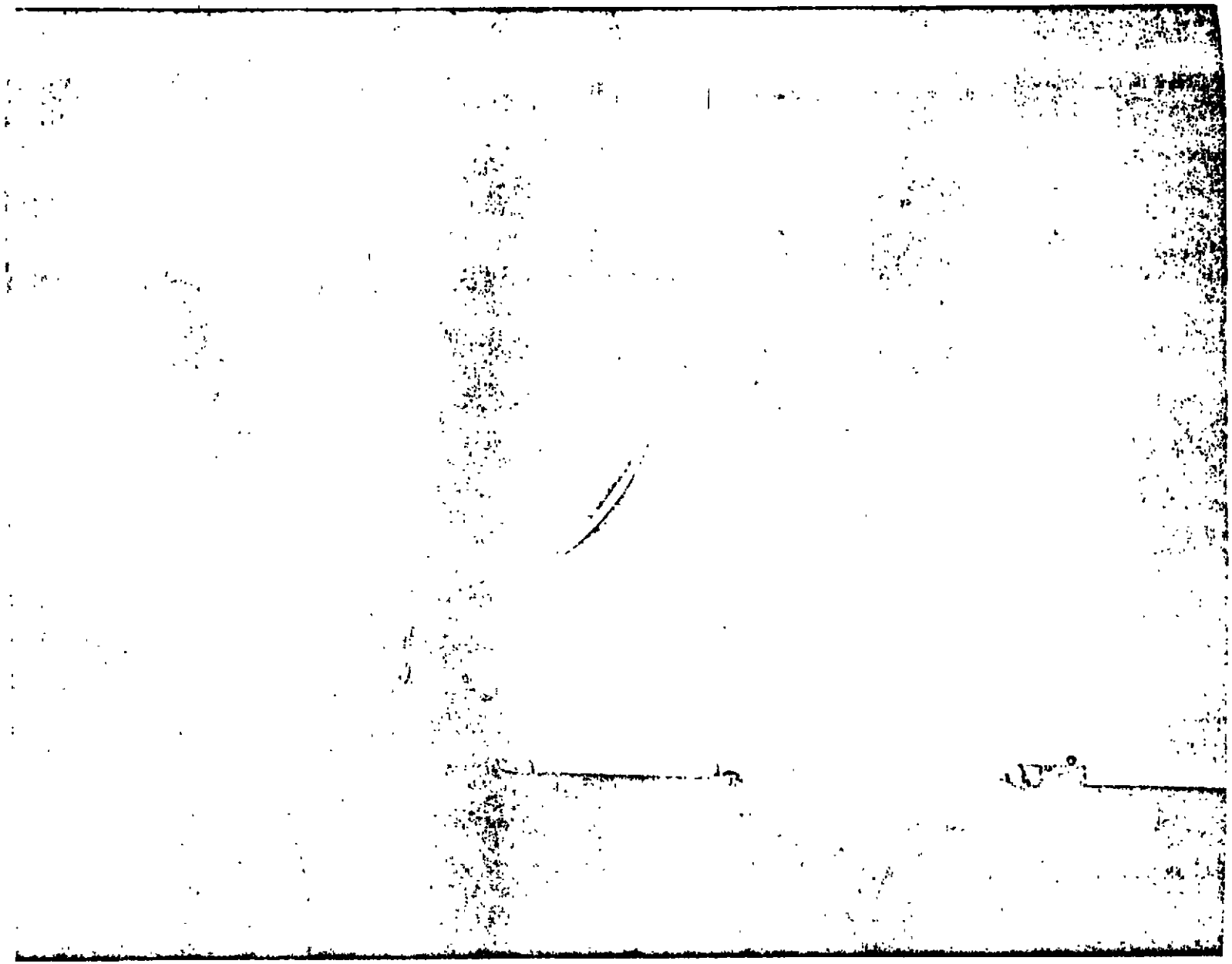

Figure 2.9 Initial flash of Franklin, with ZSG-1 air ship from Lakehurst Naval Air Station, Lakehurst, New Jersey, moored nearby to measure shock wave effects

PART V

F. C. D. A. OPERATIONS

PART V

CHAPTER 1

OPERATIONS FEDERAL CIVIL DEFENSE ADMINISTRATION

General

1.1 The Federal Civil Defense Administration was a major participant in a continental nuclear weapons test series. In Operation Plumbbob FCDA accomplished its objectives by assisting in the staffing of the joint Office of Test Information, executing an extensive observer program, and by placing major emphasis on technical tests designed to obtain data on the effects of nuclear weapons required for civil defense planning.

Background

1.2 FCDA started its participation in nuclear weapons tests in the Spring of 1951 by sending observers to Operation Greenhouse and has sent observers to all other Pacific tests since.

1.3 In the Fall of 1951, the Buster-Jangle series, Agency test activities began with a limited test program to test backyard shelter prototypes of wooden construction and to train FCDA staff personnel in radiological monitoring techniques.

1.4 In the Spring of 1952, the Tumbler-Snapper series, FCDA played a major role in justifying and operating the first "open shot". State Civil Defense Directors and several governors were present as FCDA invitees. Invited were approximately 60 civil defense observers and nearly 300 members of the press, radio, television, and motion pictures. There were no associated technical tests available for inspection by the observers.

1.5 The Upshot/Knothole (1953) series marked the first major Agency participation. The technical program included tests of backyard and basement shelters, determination of failure patterns of typical residences, extensive tests of passenger vehicles in cooperation with the automotive industry, tests of drugs and biologicals in cooperation with the Food and Drug Administration, tests of air zero locators and radiological defense instruments, and evaluation of comparative blast resistance of a large variety of curtain walls and partitions. The latter was conducted in close cooperation with the Department of Defense.

1.6 FCDA also played a principal role in the justification and conduct of the 1953 "open shot", which was witnessed by about 300 civil defense and State and local government officials. This observer program was conducted in cooperation with the Atomic Energy Commission and the Department of Defense who had an equal number of representatives.

1.7 In the Spring of 1955, Operation Teapot, the test series included a rather comprehensive civil defense program designed to meet all Agency objectives. A single shot was selected for most of the Agency participation although some programs extended through the entire series. The single shot was opened to uncleared observers and to industry participants without clearance for Restricted Data. This event was known as Operation CUE. The technical participation consisted of determining the nuclear effects on residential, commercial, and industrial structures; foods and foodstuffs; shelters for civilian populations; utilities; mobile housing; and emergency vehicles. It also included radiological defense studies.

Objectives

1.8 All civil defense participation is designed to meet one or more of the following general objectives:

To conduct research programs under conditions provided only by nuclear detonations in order to develop basic technical information.

To "proof test" equipment or structures. Often the final step in design is to subject the equipment or structure to actual nuclear detonation conditions. The results are often predictable when testing such things as shelters, but since many human lives may be involved, actual field tests must take place.

To train specialists in various phases of nuclear defense activities.

To indoctrinate key civil defense personnel, and State and local officials, with civil defense responsibilities.

To assist in carrying out the FCDA responsibility for public education on nuclear weapons effects.

Mission and Operations

1.9 Emphasis in the Spring of 1957, Operation Plumbbob, was given to tests of mass shelters and to radiological defense techniques. Four programs, which included 22 projects, were conducted by FCDA personnel or FCDA contractors. In addition, FCDA was co-sponsor with the Department of Defense, the Atomic Energy Commission, and the Food and Drug Administration for nine other projects. The FCDA done shelter projects were conducted in the closest cooperation with related Department of Defense programs.

1.10 Training activities were expanded and included indoctrination and field experience in radiological defense for both "Q" cleared State and local personnel and for uncleared personnel.

1.11 FCDA technical test activities were conducted in Nevada under the Civil Effects Test Group. This Group was principally sponsored and supported by FCDA and the AEC Division of Biology and Medicine.

1.12 A number of other Government agencies were invited by FCDA to participate in the Nevada tests, usually to conduct tests within their particular competence, to meet Civil Defense objectives. These included the Food and Drug Administration, the Department of Agriculture, Bureau of Standards, Public Health Service, Defense Air Transport Administration, Army Chemical Corps, Army Quartermaster Corps, and the Civil Air Patrol.

1.13 Industry participation deserves special mention. The methods and procedures were developed by FCDA in 1953 and have been used in every continental test series since. If industry is in need of information not otherwise available, and if there is Civil Defense value to be derived, FCDA sponsors the industry proposal, Industry pays its own way. Since 1953, the cash value of industry participation has increased steadily. This year, the total cumulative figure probably has passed two and one-half million dollars. Over 200 companies, institutes, and associations have played some part in FCDA test activities. Their contributions have ranged from providing materials to conducting major tests.

1.14 Testing of Civil Defense shelters for foreign governments in 1957 was a "first". Through the cooperation of AEC and the Departments of State and Defense, FCDA was able to accede to requests from the French and West German Governments to test shelter designs. Actual conduct of the tests was by American contractor personnel acting as agents for the governments concerned.

1.15 The shelter program was designed to obtain basic criteria for the design of shelters which included dome, dual purpose, and family type shelters. In addition to this, there was an industry sponsored test conducted on a blast resistant vault. Included also for the first time were two projects in which foreign shelters were tested.

1.16 The objective of one of the projects was to obtain engineering data for design, load, response, and mode of failure on dome type mass shelters and on the shelter door. Three 50-ft-diameter reinforced concrete dome shelters were constructed at three ranges, 20, 35,

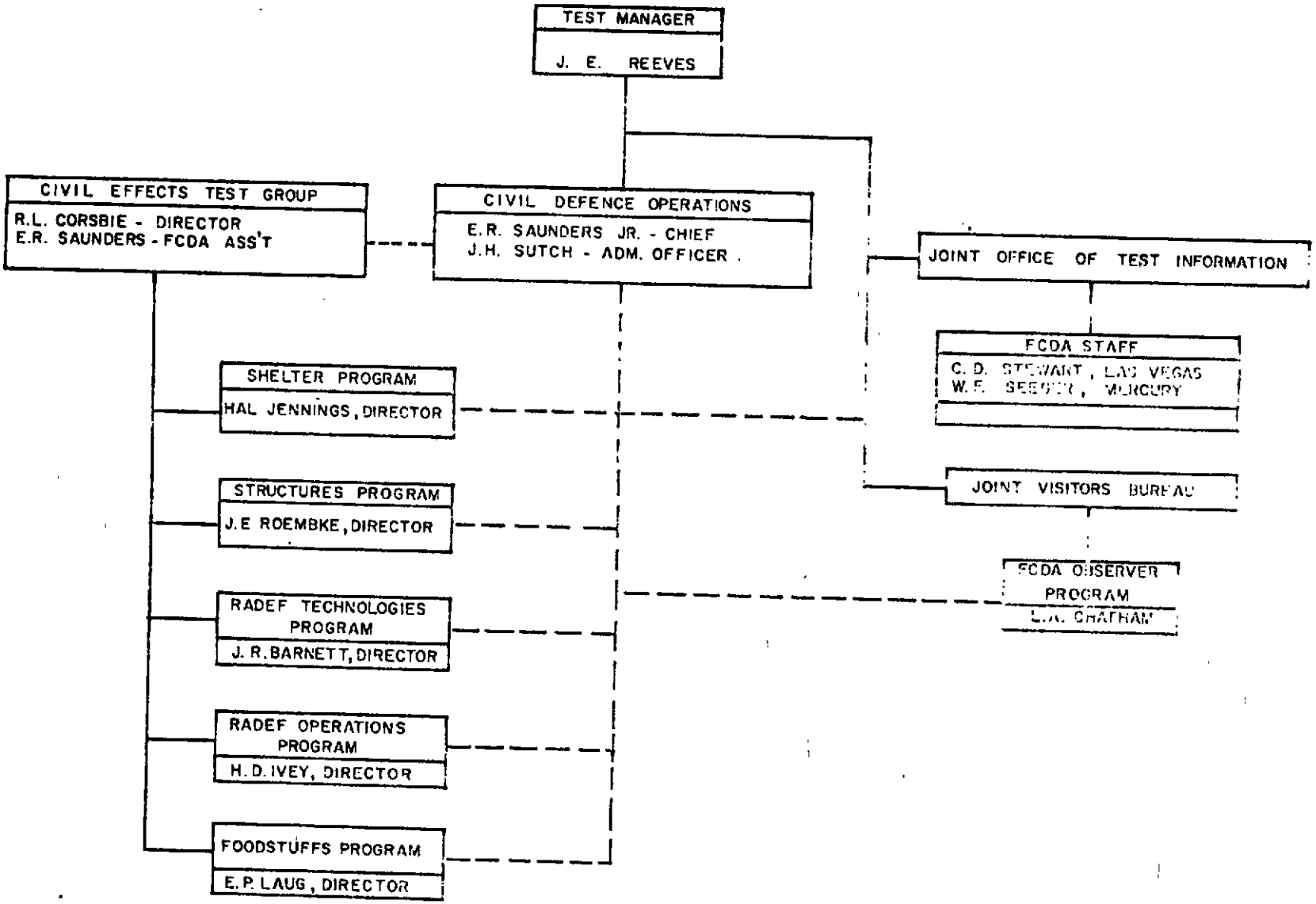

FIGURE I.I FCDA ORANIZATION, OPERATION PLUMBBOB

and 70 psi side-on overpressure. The results of the test were as anticipated when taking into account that the structures were subjected to a slightly higher overpressure than expected. An ideal pattern of damage was obtained in that the close-in dome was completely destroyed, the center dome partially destroyed, and no apparent damage was done to the dome at 20 psi. The only damage done to the prototype door was that of stripping off the upper outside flanges; hence the steel door tested made an effective closure.

1.17 A rectangular dual purpose underground garage and mass shelter with an automobile ramp and blast door was tested at an anticipated 35 psi side-on overpressure range. This project was included to determine engineering data for the design, loading, and response of this type structure. The apparent damage inside of the structure resulting from the detonation was that of slight spalling around the base of a center support column. The damage done to the ramp and end side retaining wall was considerable.

1.18 Also tested were three reinforced concrete family shelters which were constructed at anticipated pressures of 30, 48, and 65 psi. The objective was to gain additional engineering data to accomplish a more economic design. The only apparent damage done to any of the structures was that of bending the vent pipes away from the direction of the blast and a slight dishing of the steel entrance way of a shelter closest to Ground Zero.

1.19 A blast resistant vault and door, financed by the Mosler Safe Co., was tested to verify the theoretical analysis of the behavior of such a structure at a high pressure level. Defraction pressures and patterns resulting from an overpressure in excess of 75 psi were obtained. The damage was confined mainly to stripping of the front portion of the reinforced concrete cover, dislodging the control knobs, and disfiguring and charring the ornamental stainless steel. When the combination was set, the seven ton steel door was easily reopened. There was no apparent temperature or pressure increase inside of the vault, thus giving adequate protection to its contents.

1.20 The FCDA sponsored tests of French and West German underground personnel shelters. The French underground structures tested were as follows: One rectangular shelter; one cylindrical shelter; two entrance ways at an anticipated pressure of 132 psi; and one entrance way at 118 psi. Also included in the foreign shelter test program were seven West German rectangular shelters and two cylindrical shelters located at pressure ranges from 7.4 psi to 265 psi. The data gained is being evaluated for design improvements and the establishment of design criteria. The actual pressure was considerably less than that anticipated therefore incurring only minor damage to the structures.

1.21 A project was established to provide loading and response measurements for the various structures in the shelter and structure programs. The instrumentation provided measurements of loading, acceleration, shear, strain, deflection, and time history curves.

1.22 A second program was established to verify blast resistant designs of structures, equipment, devices, and components and to furnish data for the improvement of these designs. Included also was a test of air zero locators.

1.23 Civil defense operations, following an attack with nuclear weapons, would be facilitated if a network of suitable devices for indicating the position of the explosions was provided to keep all target areas under continuous surveillance; therefore, several types of air zero locators were tested including the reflecting and refracting type of Eastman Kodak, the National Bureau of Standards pinhole camera type, and spherical plastic type designed to determine the position of nuclear detonations. The refracting type air zero locator appeared to be the most promising.

1.24 In previous tests, reinforced brick masonry structures were compared unfavorably with reinforced concrete structures. The

Structural Clay Products Research Foundation has developed a design which is highly resistant to blast loads. This design has proved effective in field tests utilizing conventional high explosives. One windowless model building and six wall specimens were designed and built to investigate their behavior when subjected to low overpressures. The objective of this project was to evaluate the structural resistance of reinforced clay masonry to the effects of a nuclear detonation. There was little or no damage done to the reinforced structures; however, the nonreinforced brick panels at two pressure ranges suffered major damage.

1.25 The need is evident for reducing the damage to doors and eliminating the missile hazard resulting from doors becoming dislodged in low overpressure blast areas where otherwise the damage would be minor. Therefore, five test doors of different designs were mounted in cells at anticipated pressures of 3½ to 7 psi. The objective of the project was to establish design criteria for commercial doors under low intensity overpressures from blast loading. There was little or no damage done to all of the doors with the exception of the hollow plywood door at the 7½ psi range. This door was completely demolished.

1.26 In order to prevent injury to occupants and damage to filters and other equipment, blast resistant closures must be provided for all ventilation openings in protective structures. Therefore, tests were made on the performance of several types and sizes of pressure sensitive antiblast valves for ventilation openings. All valves appeared to withstand the blast with no damage and effected adequate closure.

1.27 FCDA has been charged with the responsibility of determining the extent of the radiological hazard should this country be attacked with nuclear weapons. It appears that the most efficient and expeditious means of accomplishing this objective is by an aerial survey. An agreement has been entered into with the New York Operations Office of the AEC to design and develop instruments to accomplish this mission. A project was established to test the calibration and utility of these high level survey instruments. An aircraft was flown in patterns over areas of known activity, and excellent correlation was obtained with the ground reading.

1.28 Since the radiological hazard, in the event of a nuclear war, will be of prime importance, a program was designed to give technical data necessary for the formulation of specifications for radiological instruments, establishing nuclear radiation shielding requirements, outlining decontamination procedures and radiological survey techniques.

1.29 A project was included in this program to continue the study and evaluation of gamma radiation intensity as a function of shielding and time.

1.30 Included also was a project with the following objectives:

To conduct training in, and a demonstration of, decontamination countermeasures.

To evaluate the effectiveness and feasibility of methods of decontamination devised for various structures and areas.

To obtain data on the radiation exposure attendant to these operations.

1.31 To establish radiological defense monitoring techniques, it was necessary to--

Obtain further experience in evaluating aerial, automotive, and ground monitoring surveys.

Evaluate attenuation factors for mobile survey methods and time-lag factors for various survey instruments.

Evaluate aerial survey equipment developed for civil defense use.

Obtain data on radiation exposures associated with these surveys.

1.32 Since FCDA is procuring, distributing and stockpiling radiological instruments, it is necessary to evaluate these instruments under field conditions. The cost of FCDA's radiological instrument stockpiling is over ten million dollars.

1.33 Data and instruments alone do not comprise a radiological defense operation program, therefore, it was necessary to further study radiological defense operations techniques and philosophies. In addition to obtaining the previously mentioned information, this program also provided training in contaminated areas for Federal, State and local personnel and would serve to give a clearer definition of the responsibilities assigned to the radiological monitor. The information obtained in this program will also be used to develop manuals and training materials.

1.34 Three of the projects included in this program provided operational information and training.

1.35 Under an FCDA contract, the Department of Agriculture photographed the radiological defense operations at the Nevada Test Site. They will edit and provide to FCDA a completed movie film for training and visual aid purposes and to further study the refinement of radiological defense operations.

1.36 A project was included in Operation Plumbbob which was directed by the Civil Air Patrol to--

Continue the study of aerial monitoring techniques.

Develop training material for aerial monitoring.

Gather data for Radiological Defense manuals for CAP or other aerial survey units.

1.37 Under the FCDA delegation authority, the Food and Drug Administration made fallout studies on raw agricultural products to--

Determine the relative effectivness of various types of food packaging.

Determine methods of decontamination.

Determine risks involved in recovery of foods.

1.38 In addition to the fallout studies, the Food and Drug Administration conducted a study of resistance of vacuum glass containers procured under the FCDA medical stockpiling program. This determination is of necessity due to the fact that FCDA has stockpiled over 25 million such containers.

1.39 In addition to the previously listed FCDA directly sponsored programs, the Agency also gave about 45% of the financial support required for the "Biological Assessment of Blast Effects" Program. FCDA also financially supported several of the projects in the "Instrumentation and Dosimetry" Program since it utilized some of the services provided by that Program.

1.40 The Agency also provided two professional personnel and some financial assistance to the "Radio-Ecological Aspects of Nuclear Fallout" Program.

1.41 The FCDA observer program was designed to broaden the understanding of nuclear weapons effects of persons with civil defense responsibilities and affiliations. It also served to acquaint these selected personnel with the FCDA technical test program and provided an opportunity for them to obtain FCDA policy through interrogation of the Director of FCDA Test Operations and staff.

1.42 Provisions for admitting civil defense observers were established by the Atomic Energy Commission, the Department of Defense, and FCDA. Observers were required to submit citizenship statements in advance of their arrival and to complete a detailed information registration card upon acceptance of the invitation. The foreign observers were certified by the State Department and through the foreign observers' respective Washington Embassies.

1.43 The FCDA Observer Program became operational on May 1, 1957, with the establishment of the Las Vegas office in the AEC Branch Of-

fire two weeks prior to the scheduled readiness date of the first test detonation of the Operation Plumbbob series. The FCDA Las Vegas office coordinated all details of the observer program with the AEC Visitors Bureau at Mercury and with the Director of FCDA Test Operations at Mercury. All professional personnel of the FCDA Joint Visitors Bureau strictly adhered to the concept of joint team operation regardless of whether their parent agency or service had an interest in the matter involved.

1.44 Planning and preparation of schedules were set up for the observers for preshot, postshot, and shot date trips to Mercury from Las Vegas. Preparation was made for briefing materials for preshot and postshot tours which also included special civil defense publicity releases for civil defense observers' home town newspapers. This required coordination with the AEC Joint Visitors Bureau at Mercury and the Office of Test Information in Las Vegas.

1.45 Nine shots originally were scheduled for FCDA Observers. Due to several lengthy postponements caused by unsuitable weather conditions and technical difficulties, a number of additional shots were declared open by AEC. Out of a total of 24 shots scheduled from May 1st through October 7th, FCDA observers were in attendance at 13 of these. This was effected through special arrangements with the Director of FCDA Test Operations and the AEC. In many instances, clearances had to be established for FCDA observers by contacting the AEC office in Washington. Usually these requests for clearances were granted.

1.46 There was a total of 238 civil defense registrations during the series. Approximately 202 observers witnessed a detonation. Due to the numerous delays occasioned by weather postponements, many of the observers found it impossible to remain a sufficient length of time to witness a shot. There was a total of 47 postponements on the open shots witnessed by FCDA Observers. The series had a total of 91 postponements on all scheduled shots. In addition to the 202 FCDA civil defense observers, 31 foreign observers from 10 countries witnessed a detonation, making a total of 233 persons to see a shot.

1.47 All observers were given preshot briefings and a complete tour of the Nevada Test Site showing FCDA installations and tests into all accessible areas. In a number of instances, postshot briefings and tours of the installation were made due to the readiness and a detonation time being moved up. Every effort was made to provide all information requested by each observer before leaving Las Vegas and even informal briefings were provided by the Director of the FCDA Test Operations and technical staff members in Las Vegas. Every effort was made to provide all observers with a preshot tour and briefings even though they were unable to stay to witness a shot. Many of these observers expressed deep satisfaction for having received this important information.

1.48 The FCDA Observer group included a cross section of Government, State, county, and city officials as well as a large number of observers who have a direct interest and responsibility in the National and local Civil Defense programs.

1.49 The Federal Civil Defense Administration furnished a portion of the Joint Office of Test Information for Operation Plumbbob. Consistent with this agreement, FCDA supplied two public information specialists and provided secretarial staff for the entire series.

1.50 Early in the operation, a series of news releases detailing the projects sponsored by FCDA were prepared and released after clearance by OTI. These releases contained information on shelter tests, tests of shelter components, French and German shelter tests, radiological training activities, and projects involving radiological defense projects. All of these releases received widespread publication.

1.51 Special FCDA information activity was undertaken in connection with only 2 of the 24 test shots. The inclusion of FCDA designed shelter tests in the Priscilla shot was exten-

sively publicized with advance stories detailing the purpose of the tests and postshot photographs of home, dual purpose, and mass shelters being distributed to new media.

1.52 A special press briefing was held when results of the shelter tests were available, with the press being given printed reports by the Director of the Civil Effects Test Group and the FCDA Program Directors and postshot pictures of the shelters, the Mosler bank vault, a modular school unit, doors, clay masonry construction, and blast valves were tested in the Priscilla shot. These photographs were reprinted by many newspapers and were used in an FCDA shelter pamphlet and in the FCDA Newspicture Page distributed to some 7500 newspapers.

1.53 Stories and advance construction photographs were issued on the French and German shelters involved in the Smoky shot. Special releases and photographs were issued about the presence of State and city trainees during a Radiological Defense course and in connection with the presence of a California Disaster Service radiological monitoring squad for field training. A story was released on a decontamination project involving fire chiefs from Las Vegas and a number of California cities. Special home town releases were prepared and distributed reporting the presence of individual members of the radiological defense training groups and photographs were supplied to trainees. FCDA OTI personnel also wrote and distributed home town news releases reporting the presence of all civil defense observers at open shots--the total approximating 500.

1.54 FCDA assisted the AEC in briefings and guiding of field tours for the Holifield Committee staff, the National Security Council, Dr. Libbey (AEC Commissioner), and other AEC observer groups. The FCDA Administrator, Deputy Administrator, and several Assistant Administrators attended the Test Site and were briefed on nuclear weapons effects, the Test Organization, and were shown the structures tested by FCDA.

Organization

1.55 The FCDA components of the Test Organization were under the general direction of the Chief of FCDA Test Operations; however, they functioned under the "joint" concepts and answered Director to Director of the group to which they were assigned. Figure 1.1 is a block diagram showing the organization structure of the FCDA Test Operations.

Logistics

1.56 The support of FCDA programs was provided through the AEC Support Director. Support items such as materials, equipment, vehicles, and communications were made available by the Reynolds Electrical and Engineering Co. consistent with the status report requests. Labor was also obtained from REECO. The large and costly FCDA sponsored structures were constructed by an AEC lump-sum contractor.

Funding

1.57 Financing of FCDA sponsored projects during Operation Plumbbob was carried out in accordance with the terms of the FCDA-AEC Memorandum of Understanding dated February 7, 1957. Appropriation transfers totaling $1,644,600 have been made to AEC to cover the cost of all FCDA programs. Designations have been made to provide FCDA assistance to other groups, notably Program 33 - $112,000; Program 37 - $15,000; Program 38 - $15,000; and Program 39 - $ 19,300. In addition to programs where FCDA funds were designated, other projects of mutual interest were supported financially by special purpose work orders.

Conclusions

1.58 In general the FCDA considers Plumbbob a very successful operation in all phases of its participation which includes the FCDA Observer Program, its component of the Joint Office of Test Information, and its technical tests. From the comments and letters received, the FCDA Observer Program was successful in educating and stimulating interest in Civil Defense.

1.59 The Technical Test Program was considered successful in that the results verified theoretical calculations, and there was no significant data lost. The tests provided an opportunity to thoroughly study radiological defense operations and provided training to a large number of State and local personnel in radiological defense.

1.60 FCDA has raised questions as to the adequacy of construction and inspection and the need for closer control over construction. There exists a corollary problem of lead time in the development and approval of drawings and specifications. A question of the length of time in furnishing cost reports was also raised. These questions will be considered by the NTO and efforts made to resolve the problem prior to future continental test operations in which the FCDA participate.

1.61 Consideration relative to establishment of FCDA as a separate Test Group is discussed in Part I, Chapter 6. Operational Problems.

Recommendations

1.62 Prior to the next continental test operation, FCDA and AEC Representatives consider the establishment of joint operating procedures with view to resolving procedural problems indicated in paragraph 1.60 above.