NEVADA TEST ORGANIZATION 410492

Nevada Test Site
Mercury, Nevada

BACKGROUND INFORMATION

on

NEVADA NUCLEAR TESTS

A summary of previously-released information providing answers to questions concerning the need for and value of nuclear tests, past use of the continental test site, on-site operations and controls, public safety, and some phases of organization and programs.

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Revised to July 15, 1957

FOREWORD

A large volume of official information has been issued concerning Nevada nuclear testing since Nevada Test Site was activated in January 1951. The information made public has been contained in official publications and reports of the Atomic Energy Commission, the Department of Defense, the Federal Civil Defense Administration, other Federal organizations, and the joint Nevada Test Organization.

Prior to the Spring 1952 series, the Test Organization received many requests from newsmen, from public officials, and from representatives of Federal agencies for a compilation of officially-approved basic information to be used as a source book. As a result the first compilation of Background Information was issued during the 1952 series.

In order to meet similar requests, the information summary has been brought up-to-date for each subsequent Nevada Series, incorporating data released officially in the interim period.

The present Background Information is such a compilation. It does not attempt to be all-inclusive. Many supplementary details are available elsewhere, for instance in the 1957 revision of "Atomic Tests in Nevada," the various semiannual reports of the AEC to Congress, and the Government publication "The Effects of Atomic Weapons." Such publications are usually available in public libraries.

All material summarized here has been officially released previously, following security and classification review by the Federal agency with primary responsibility for the subject matter.

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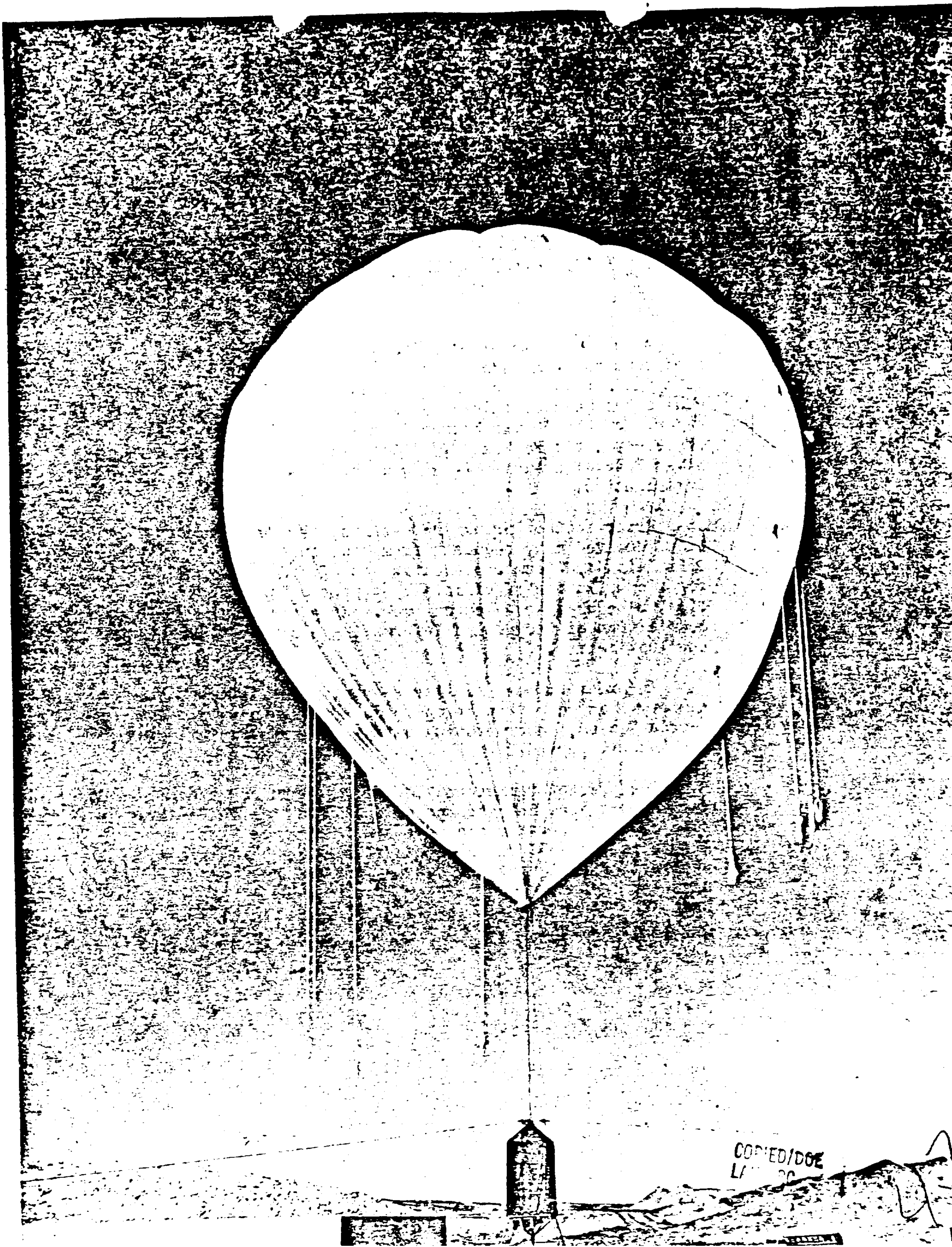
← CLOUD FOLLOWING NUCLEAR DETONATION IN NEVADA



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A SHOT BALLOON AT NEVADA TEST SITE

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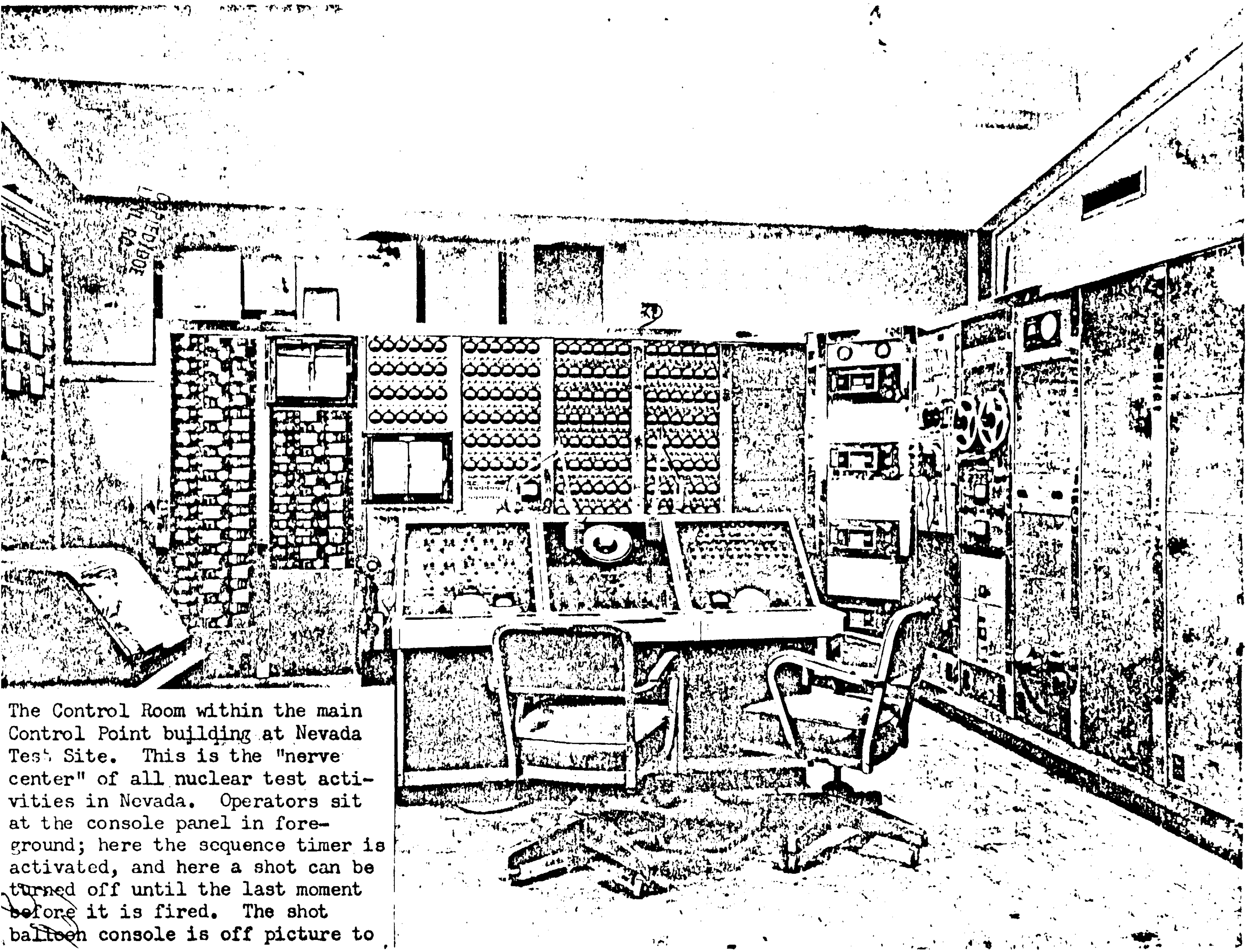

The Control Room within the main Control Point building at Nevada Test Site. This is the "nerve center" of all nuclear test activities in Nevada. Operators sit at the console panel in foreground; here the sequence timer is activated, and here a shot can be turned off until the last moment before it is fired. The shot balloon console is off picture to

LIST OF ALL FULL SCALE NUCLEAR DETONATIONS IN NEVADA

Series and Date			Type of Delivery or Placement	Firing Area
Ranger — Winter 1951 Series				
Shot	1	January 27	Air	Frenchman Flat
	2	January 28	Air	Frenchman Flat
	3	February 1	Air	Frenchman Flat
	4	February 2	Air	Frenchman Flat
	5	February 6	Air	Frenchman Flat
Buster-Jangle -- Fall 1951 Series				
Shot	1	October 22	Tower	Yucca Flat
	2	October 28	Air	Yucca Flat
	3	October 30	Air	Yucca Flat
	4	November 1	Air	Yucca Flat
	5	November 5	Air	Yucca Flat
	6	November 19	Surface or Underground	Yucca Flat
	7	November 29	Surface or Underground	Yucca Flat
Tumbler-Snapper -- Spring 1952 Series				
Shot	1	April 1	Air	Frenchman Flat
	2	April 15	Air	Yucca Flat
	3	April 22	Air	Yucca Flat
	4	May 1	Air	Yucca Flat
	5	May 7	Tower	Yucca Flat
	6	May 25	Tower	Yucca Flat
	7	June 1	Tower	Yucca Flat
	8	June 5	Tower	Yucca Flat
Upshot-Knothole -- Spring 1953 Series				
Shot	1	March 17	Tower	Yucca Flat
	2	March 24	Tower	Yucca Flat
	3	March 31	Tower	Yucca Flat
	4	April 6	Air	Yucca Flat
	5	April 11	Tower	Yucca Flat
	6	April 18	Tower	Yucca Flat
	7	April 25	Tower	Yucca Flat
	8	May 8	Air	Frenchman Flat
	9	May 19	Tower	Yucca Flat
	10	May 25	280MM Gun	Frenchman Flat
	11	June 4	Air	Yucca Flat

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Series and Date			Type of Delivery or Placement	Firing Area
Teapot -- Spring 1955 Series				
Shot	1	February 18	Air	Yucca Flat
	2	February 22	300-foot Tower	Yucca Flat
	3	March 1	300-foot Tower	Yucca Flat
	4	March 7	500-foot Tower	Yucca Flat
	5	March 12	300-foot Tower	Yucca Flat
	6	March 22	500-foot Tower	Yucca Flat
	7	March 23	Underground	Yucca Flat
	8	March 29	500-foot Tower	Yucca Flat
	9	March 29	Air	Yucca Flat
	10	April 6	Air	Yucca Flat
	11	April 9	300-foot Tower	Yucca Flat
	12	April 15	400-foot Tower	Frenchman Flat
	13	May 5	500-foot Tower	Yucca Flat
	14	May 15	500-foot Tower	Yucca Flat
Plumbbob -- Summer 1957 Series				
Shot	1	May 28	500-foot Tower	Yucca Flat
	2	June 2	300-foot Tower	Yucca Flat
	3	June 5	500-foot Balloon	Yucca Flat
	4	June 18	500-foot Balloon	Yucca Flat
	5	June 24	700-foot Balloon	Frenchman Flat
	6	July 5	1500-foot Balloon	Yucca Flat
	7	July 15	500-foot Tower	Yucca Flat
	8	July 19	Air to Air Missile	Yucca Flat
	9	July 24	500-foot Tower	Yucca Flat
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NUCLEAR TEST DETONATIONS OFFICIALLY ANNOUNCED

BY THE UNITED STATES, THE UNITED KINGDOM, AND THE USRR

Compiled through April 16, 1957

U. S. Detonations	Number	Cumulative
Trinity, New Mexico, July 16, 1945	1	1
Crossroads, Bikini Atoll, July 1946	2	3
Sandstone, Eniwetok Proving Ground, April 1948	3	6
Ranger, Nevada Test Site, January & February, 1951	5	11
Greenhouse, EPG, April & May, 1951	4	15
Buster-Jangle, NTS, October & November, 1951	7	22
Tumbler-Snapper, NTS, April, May & June, 1952	8	30
Ivy, EPG, November 1952	2	32
Upshot-Knothole, NTS, March, April, May & June, 1953	11	43
Castle, EPG, March, April & May, 1954	3	46
Teapot, NTS, February, March, April & May, 1955	14	60
Wigwam, Pacific Ocean, May 1955	1	61
Redwing, EPG, May, June & July, 1956	3	64

USSR Detonations
(As announced by the U. S. Government and/or the USSR)

1949: September 23.
1951: October 3, October 22.
1953: August 12 (thermonuclear), August 23 (part of series).
1954: October 26 (part of series).
1955: Aug. 4, Sept. 24 (part of series), Nov. 10 (part of series), Nov. 23 ("largest thus far . . . in megaton range").
1956: March 21, April 2 (part of series), Aug. 24 (part of series), Aug. 30 (part of series), Sept. 2 (part of series), Sept. 10 (announced by USSR), Nov. 17 (announced same day by U. S. and USSR).
1957: Jan. 20 (part of series), March 8, April 3 (part of series), April 6, April 10 (part of series), April 12 (part of series), April 16.

United Kingdom

1952: October 3 (Montebello Islands).
1953: October 15, October 26 (both at Woomera).
1956: May 16, June 19 (both at Montebello Islands), Sept. 27, Oct. 4, Oct. 11, Oct. 21 (last four shots, all at Maralinga, constitute fourth British series).

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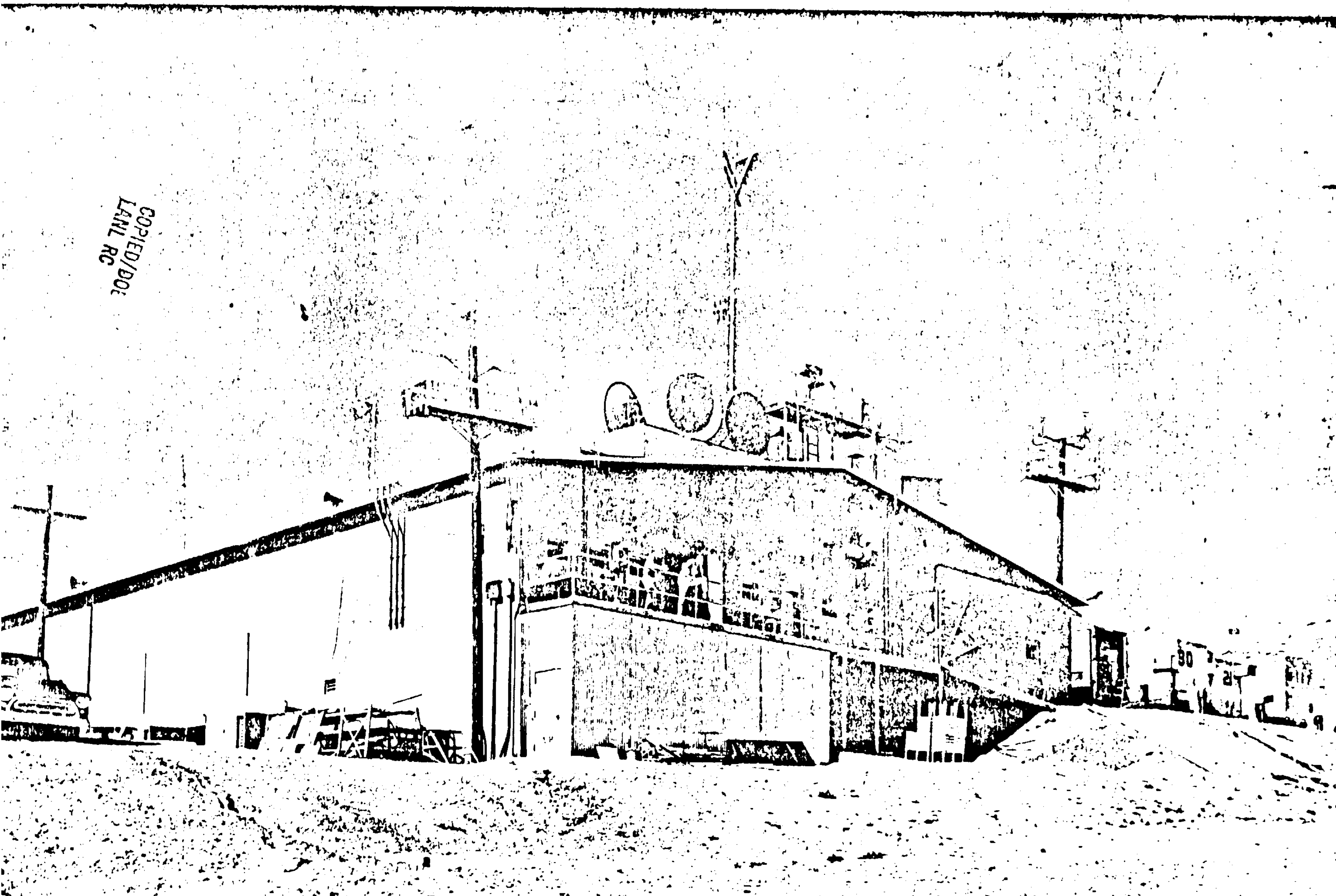
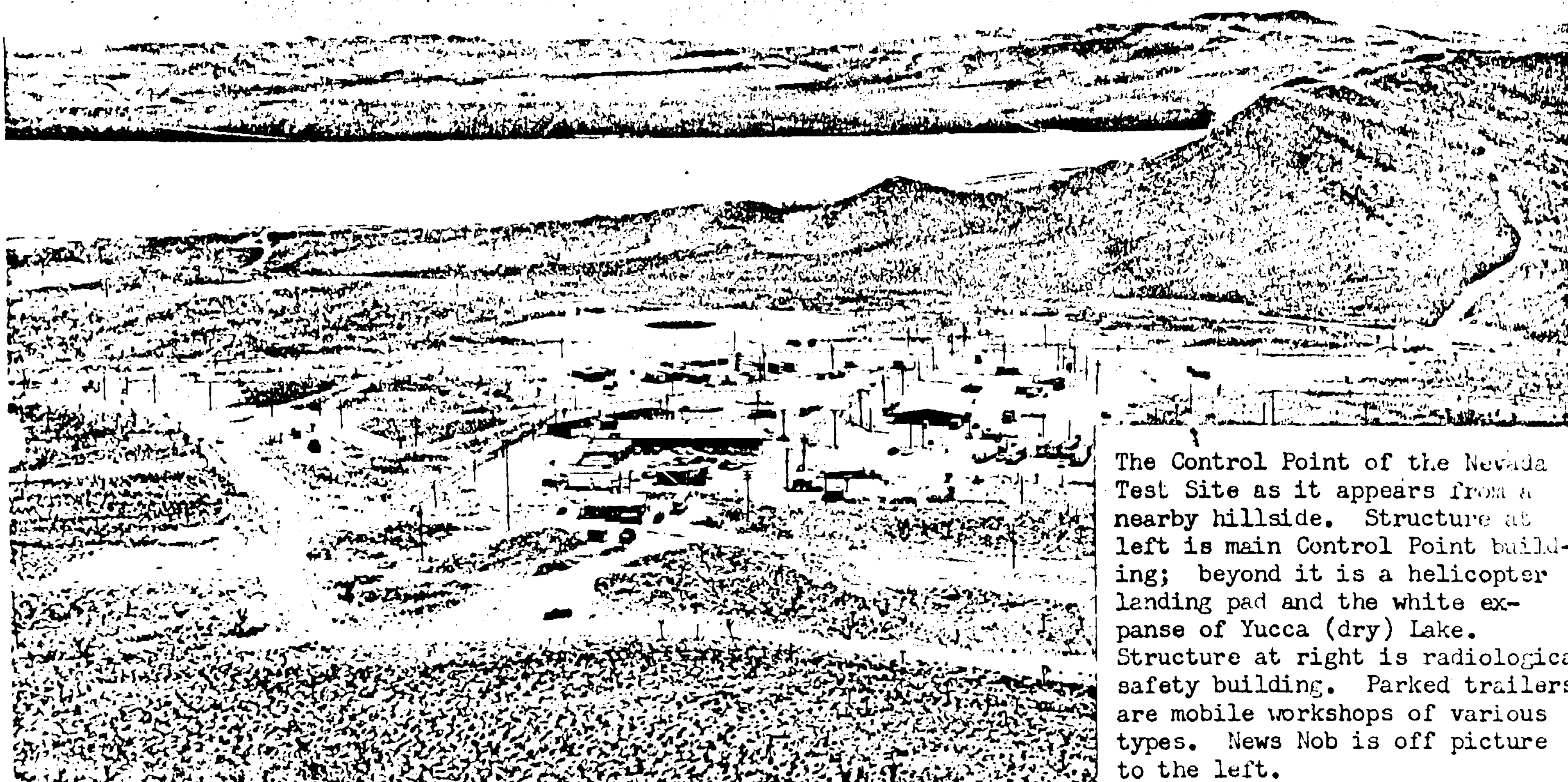


Control Point Building at Nevada Test Site



The Control Point of the Nevada Test Site as it appears from a nearby hillside. Structure at left is main Control Point building; beyond it is a helicopter landing pad and the white expanse of Yucca (dry) Lake. Structure at right is radiological safety building. Parked trailers are mobile workshops of various types. News Nob is off picture to the left.

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1. RESPONSIBILITY FOR U. S. NUCLEAR WEAPONS PROGRAMS

The Atomic Energy Commission is responsible for developing atomic weapons of requisite yield, variety, practical utility, and deliverability, and for manufacturing and putting into storage or delivering to the Armed Forces atomic weapons of the types and numbers specified in schedules established by the Joint Chiefs of Staff.

For the development of new and improved nuclear weapons, the Nation depends on the ingenuity of the scientists in its contract laboratories at Los Alamos and Albuquerque, New Mexico, and at Livermore, California, assisted by military scientists who contribute ideas and developmental concepts.

The Los Alamos Scientific Laboratory and the University of California Radiation Laboratory at Livermore (both operated for the Commission by the University of California) are concerned primarily with devising systems whereby atomic explosives may be fitted into militarily useful systems.

After such a system has been devised, it still must be fitted into an efficient and practical atomic weapon. The job of building the explosive system into a practical weapon is the primary concern of the Sandia Laboratory (operated for the Commission by Sandia Corporation, a unit of the Bell System.)

The Armed Forces are responsible for establishing the criteria for atomic weapons, for developing and producing the vehicles for delivery and mating the vehicles with the weapons, for training men in their employment, and for military defense against nuclear attack. The major point of field coordination of the Armed Forces' programs with the AEC's weapons laboratories is in Field Command, Armed Forces Special Weapons Project, Sandia Base, Albuquerque.

The Federal Civil Defense Administration is responsible primarily for determining the possible effects of nuclear attack on the civilian population, and of marshalling civilian resources for defense against such an attack.

The responsibilities of all these agencies are interconnected, and all depend upon knowledge of atomic explosive phenomena and of the effects of nuclear detonations. Field tests are fired to obtain this vital knowledge.

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2. WHY NUCLEAR WEAPONS AND DEVICES ARE FIELD TESTED

In a world in which free people have no nuclear monopoly, the United States must keep its atomic strength at peak level. That is the primary reason why tests are held periodically in Nevada and in the Pacific.

Most of the tests are intended to advance weapons development. Four areas of work are involved in the laboratory and field test development of atomic weapons: primary experimental research, theoretical investigations and calculations, component development experimentation, and full-scale nuclear detonations. If any one is neglected, the rate of weapons progress slows. The rate of testing required depends on the rapidity of generation of new ideas.

At least nine developmental purposes are served by full scale nuclear tests:

a. To proof test a weapon for desired military characteristics before it enters the national stockpile.

b. To provide a firm basis for undertaking extensive engineering and fabrication effort which must be expanded to carry a "breadboard" model to a version satisfactory for stockpile purposes.

c. To demonstrate the adequacy, inadequacy or limitations of current theoretical approaches.

d. To explore phenomena which can vitally affect the efficiency and performance of weapons but which are not susceptible to prior theoretical analysis of sufficient certainty.

e. To provide a basis of choice among existing theoretical methods of weapon improvement so as to concentrate effort along lines of greatest practical significance.

f. To determine the validity of entirely new and untried principles proposed for applications to improve performance.

g. To provide entirely new information pertinent and valuable to weapon development and arising simply as a by-product of scientific observation of full-scale detonations.

h. To gain time in very urgent development programs by substituting tests for a portion of a possible but lengthy program of laboratory calculations and experiments.

i. To provide as a by-product basic scientific information to add to the stockpile of such knowledge.

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Only for the first purpose, a proof test, would the detonation necessarily be of a weapon as such. In most circumstances, an experimental device is designed. The device tested is simplified as much as possible to answer the basic question. It minimizes the expenditure of active material. It has as low a yield as possible to minimize off-site fallout. It is seldom a useful weapon design. The information obtained from its testing will, however, immediately or eventually affect the design of stockpile weapons and improve the stockpile position.

The Department of Defense and Armed Forces have a deep interest in the conduct of full-scale tests. Full understanding of the output characteristics of nuclear weapons and their effects on various targets under varying conditions is essential to planning for the use of weapons, for planning military defenses against nuclear weapons, and for developing the desired characteristics of new weapons.

The Federal agencies charged with civil defense, biomedical studies, and with non-military applications of atomic energy have a continuing need for effects data paralleling the development of nuclear weapons. Essential civil effects information is generally in two categories, biomedical and structural, both distinct from the military effects data required by the Department of Defense. The Federal Civil Defense Administration has obtained such effects information, and additionally has trained its personnel in various test-conducted programs. In all of this broad field of study of the effects of atomic energy, it has been found that certain answers can only be obtained in the presence of a nuclear detonation. In this respect, the Nevada Test Site (and to some extent the Pacific site) is used as an outdoors laboratory for non-military applications.

While most field tests are therefore developmental in nature, the cost in material and effort is so great for any given test that every effort is made to answer with it as many other questions as possible.

Summary of United States Nuclear Tests by Series

The progressive frequency with which basic ideas have been generated and basic questions raised in weapons development and in effects is indicated by the schedule of detonations in Nevada and the Pacific. The scheduling and the number of series since 1950 should indicate also the rate at which questions have been raised and answered. Shot totals are those which have been publicly announced.

Trinity Site, New Mexico, July 1945 (one)
Bikini Atoll, mid-1946 (two)
Eniwetok Proving Ground, spring 1948 (three)

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Nevada Test Site, winter 1951 (five)
Eniwetok Proving Ground, spring 1951 (four)
Nevada Test Site, autumn 1951 (seven)
Nevada Test Site, spring 1952 (eight)
Eniwetok Proving Ground, autumn 1952 (two)
Nevada Test Site, spring 1953 (eleven)
Eniwetok Proving Ground, spring 1954 (three)
Nevada Test Site, spring 1955 (fourteen)
Pacific Ocean, spring 1955 (one)
Eniwetok Proving Ground, spring 1956 (three)

Charts showing announced world-wide test totals are at the front of this booklet.

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3. ORIGIN, HISTORY, AND VALUE OF CONTINENTAL TESTING

Trinity, 1945

World War II's crash development of atomic weapons had the benefit of a single, full-scale field test, that at Trinity (New Mexico) on July 16, 1945. There was too little fissionable material and probably too little time for more. The two weapons fired over Japan were inefficient and very bulky; they left much to be desired.

Following World War II, the Navy desired to test the effects of atomic weapons on water and on ships. Bikini Atoll was chosen as a locale because of its isolation from population centers, and because the relatively shallow and sheltered waters of the lagoon were an excellent environment for the types of tests desired. Two weapons of a type used over Japan were detonated in the 1946 operation above and below the surface of Bikini lagoon. The tests were ship-based, and were viewed by public and foreign observers, and by news media representatives.

First Developmental Tests in the Pacific

The wartime work had bypassed, for the time being, very promising principles. Los Alamos Scientific Laboratory had, in 1945-1947, opened new paths toward more efficient, more versatile weapons which needed exploration. The scientists urged a program of field tests to supplement laboratory work. The military's need for knowledge of weapons effects was no less acute.

During 1947 first thought was directed toward a continental site which would facilitate use through location and through sufficient real estate. Military and AEC personnel surveyed sites on the North American continent. It was felt that, if the weapons laboratories had a "backyard" testing site, results of such tests could be reflected in weapons development or manufacture months sooner than with overseas tests.

The determination was, however, to use an ocean site. Various factors entered into the decision. One was greater security of information at an isolated island site. Another was that the phenomena of blast and of radiation and fallout were not well understood and an ocean site, remote from any centers of population, would avoid any public hazard. The Eniwetok site was used for the Sandstone series in April 1948.

Selection of a Continental Site

The need for a backyard test site became increasingly apparent during late 1949 and 1950. The pace of weapons development had

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been stepped up, and it became clear that the program would require more frequent tests than could be conducted feasibly in the Pacific. The rate of development of new and improved nuclear weapons depended on whether or not a continental site could be utilized.

Available locations were surveyed again and checked against criteria such as: density of population; weather, particularly for its effects on radiological safety locally and nationally; operational factors such as air lanes, labor pool, transportation; real estate available to the government; and security. The Nevada site, then a portion of the Air Force's Las Vegas Bombing and Gunnery Range, most nearly satisfied all of the criteria for a continental site.

Careful review of all available research and test data relating to fallout and to blast indicated that under the controls planned, relatively low power tests could be fired with adequate assurance of public safety.

The decision to establish a continental test site was made in December, 1950, and the Nevada Test Site was first used for an atomic test on January 27, 1951.

Numbers and Types of Detonations

Forty-five weapons, weapon prototypes, or experimental devices were fired in five series in Nevada between January 27, 1951, and May 15, 1955. All were relatively small in yield, ranging from less than one kiloton (equal to 1,000 tons of TNT) to considerably less than 100 kilotons. These yields may be compared with the tremendous explosive force of the larger weapons or devices included among those tested in the Pacific, with ranges having been announced of up to about 500 kilotons for fission bombs and up to millions of tons (megatons) for thermonuclear devices.

Of the 45 detonations, 22 were tower placements, 19 were air drops, three were surface or underground placements, and one was a 280 millimeter cannon shot. The details of detonations by series and by shots are given in a chart at the front of this compilation.

Uses Made of Individual Nevada Tests

A sizeable majority of the shots have been primarily developmental, of devices conceived by scientists in the Los Alamos Scientific Laboratory and the University of California Radiation Laboratory branch at Livermore, and constructed by those laboratories with the assistance of Sandia Laboratory. Los Alamos devices have been tested in all series, while Livermore entered the continental testing program in the spring 1953 series.

Other shots have been primarily for military weapons effects, but almost all have been used to answer both diagnostic (for weapons development) and effects questions (for military or civilian agencies). For example, one recent series had 24 formal technical programs, of which seven were diagnostic, nine were for military effects, and eight were for civil effects.

Experiments to measure the effects of atomic weapons, from the military viewpoint, are conducted under the technical direction of the Armed Forces Special Weapons Project, through its Field Command Weapons Effects Tests Division, Sandia Base, Albuquerque. The experiments are conducted by laboratories and organizations of the Armed Forces, by their contractors, and by cooperating laboratories of other government agencies. These experiments have included tests of blast effect on structures, on military aircraft and other vehicles, on material and military-type installation, on various types of surfaces such as lakes or forests, and have included biomedical studies using large and small animals.

The civil effects program includes experiments and studies to determine the structural and biological effects. These are conducted under the direction of the AEC's Division of Biology and Medicine. Participating are AEC National Laboratories, the Federal Civil Defense Administration, educational institutions, private medical or research institutions, and private industrial organizations.

Essentially as part of the civil effects program, there have been continuing scientific projects for study of radiation effects through off-site fallout. These projects have included efforts to document intensity patterns, particle size, and radiostrontium deposition. Field studies have been made on the way fallout particles are taken up by plant life, then by rodents and other plant-eating animals, and finally by larger meat-eating animals which prey on rodents. Laboratory rodents and larger animals have been used in biomedical effects programs. The rats and mice used have been of specially bred laboratory strains with known characteristics. The information gained has influenced the safety of all individuals exposed to radiation, provided additional safety to workers in the atomic energy program, helped safeguard and prepare military personnel against possible enemy attacks, and helped citizens throughout the Nation prepare for self-protection in case of enemy attack.

Other uses include military observation, troop maneuvers, and flyover training; and Congressional, civil defense, and news correspondent observation.

Three Nevada shots have been opened to Civil Defense observers, public officials, and news representatives: April 22, 1952; March 17, 1953; and May 5, 1955. These and other shots have involved major FCDA experiments and training for FCDA personnel.

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More background details on the military and civil defense participation are given in Section Five.

Small to large groups of Congressmen and other public officials have attended many detonations in all Nevada series. A group of NATO observers witnessed the May 5, 1955, shot.

Costs of Nevada Tests

Exact costs of Nevada test operations, even aside from the cost of fissionable materials expended, have not been segregated and probably cannot be. It was estimated that the cost of the originally-scheduled ten shots in the Spring 1953 series would be about $15,000,000 for the AEC and about $15,000,000 for the DOD, or approximately $3,000,000 a shot. This still may be a fairly rough estimate.

Postponements

In the five series, there were approximately 103 postponements or delays. More than 80 were caused by unacceptable weather. Other causes included: aircraft engine failure, one; construction, one; delays in instrumentation, three; aircraft operations, two; contamination of firing areas by previous shots, two; one shot was prevented from detonating by a built-in checking device when a key experiment was not receiving data; another did not detonate because of failure in an electrical connection. A majority of postponements for weather were day by day, but when air drops were involved the initial postponement was usually 48 hours.

Operating Controls

Controls and procedures to prevent hazard to on-site participants or to the off-site public have been successful. Only one person, a test participant, has been injured seriously as a result of the 45 detonations. Outside the Test Site, there has been no instance of hazardous exposure of human beings to radiation from fallout, and no injury from blast waves or the flash of light. There were instances of property damage, such as broken windows, from blast in the Las Vegas area and in St. George -- mainly confined to earlier series. Cattle and horses grazing within a few miles of the detonation suffered skin deep beta radiation burns on their hides (1952 and 1953 series), with no effect on their breeding value and no effect on the cattle's beef quality. Radiation fallout more than a few miles from the detonation has been in quantities harmless to humans, animals or crops.

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Claims Arising from Nevada Tests

Since testing began in Nevada in 1951, approximately 640 claims have been filed against the AEC through administrative channels as a result of alleged test-connected damage or injury. Of the total, 432 were filed as a result of the first two series in 1951 mostly as a result of alleged structural damage from blast effects, and 384 claims were settled by payment to the claimants of a total of $44,352, which represents more than three-fourths of the $53,624 paid out for claims to date.

Test series since 1951 have resulted in about 200 claims. Of these only 14 have been found justified, and they have been settled through payment of $9,282. The 1955 series resulted in 67 claims, of which only four resulted in settlements involving a total of $1,465. Two of the four claims settled were for the loss of turkeys which were stampeded on two turkey ranches in California by the blast of a nuclear detonation.

All claims other than those noted as having been settled have been denied. No claim has ever been settled on the basis of alleged biological injury to humans, although the AEC compensated the owners of some horses which were grazing very near the Test Site, within the boundaries of the Las Vegas Bombing and Gunnery Range, and which received beta burns. Amount of the settlement was $5,900.

The AEC may settle claims of up to $5,000 through administrative processes. Claims for more than that amount must be sought through court action. To investigate and recommend action on certain claims filed through administrative channels, the AEC has retained the General Adjustment Bureau, which maintains an office in Las Vegas during test periods.

Suits in Federal Courts

In addition to claims filed through administrative channels, 12 suits have been filed in U. S. courts seeking a total of $1,031,909 for asserted damages or loss of property as a result of Nevada tests.

One suit, filed by the Bartholomae Corporation in the U. S. District Court for California, Southern District, sought $5,000 from the AEC for alleged blast damage to structures at the corporation's Fish Creek Ranch near Eureka, Nevada. In November, 1955, the court ruled in favor of the AEC and disallowed the claim. It is understood that an appeal has been filed.

Elma Mackelprang and Dewey Hortt sued for $200,000 in the U. S. District Court for California, Southern District, alleging personal radiation injury. These cases were eventually consolidated, and all culminated on October 25, 1956, when the Federal judge signed

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an order of dismissal, thereby, for all practical purposes, putting an end to this litigation. The plaintiffs' attorney entered into the stipulation on which the dismissal was founded on the basis that he could not support his case with the evidence available.

Seven suits were filed in the Utah District Court by Southern Utah sheepmen alleging death of their sheep, stunted growth, and failure to produce lambs in the usual number, supposedly as a result of fallout from the 1953 tests. The suits asked $226,309. The Federal judge decided against the plaintiffs and for the AEC when the case was heard in the fall of 1956.

The Sheahan family, operators of the Groom Mine near the Test Site, have sued the AEC and the U.S. Air Force for $450,000 in the U.S. Court of Claims, alleging the taking of their mining property. In the suit they claim they no longer are able to operate the mine because of nuclear testing and because of Air Force bombing operations on the Las Vegas Bombing and Gunnery Range which adjoins the test site. Based on their allegation that they can no longer operate the mine, the owners assert that the government agencies have in effect condemned and taken the property. This case has not been decided.

Mr. and Mrs. Daniel Sheahan have also sued the AEC for $75,600 in a separate suit in the Federal District Court for Nevada, alleging that Mrs. Sheahan developed a facial cancer as a result of asserted burns from radioactive fallout in the 1952 series. The suit is pending.

Value of a Continental Site to National Programs

The five test series in Nevada have demonstrated that the continental test site is even more valuable than had been anticipated. Despite rigid limitations on yield, Nevada tests have clearly demonstrated their value to all national atomic weapons programs. Each Nevada test to date has been succesful in adding to scientific knowledge needed for development of atomic weapons, and needed to strengthen our defense against enemy weapons.

Possession of a continental test site has perhaps doubled the rate at which knowledge has been gained in the fields of weapon design and weapon effects. Nevada tests have made it possible to design weapons suited to a wide variety of strategic and tactical situations, and fitted to different military delivery vehicles.

Together with tests in the Pacific, Nevada tests have made it possible to increase by very sizeable amounts the efficiency of stockpile weapons. As a result of the nuclear field test program the United States has developed a whole family of weapons, with large yields and small. Because of the tests, the Armed Forces are stronger and Civil Defense better prepared.

The weapons laboratories' backyard workshop in Nevada has permitted tests to be set up quickly and to be conducted more frequently than would have been possible in the Pacific. It has resulted in major savings in time for weapons development, the most important factor, and in utilization of scientific and technical manpower, and in money.

The following are brief summaries of the value of the Nevada Test Site to the three major types of participants:

> AEC Weapons Laboratories. "The value of a continental site is quickly proved by examination of the test schedules, the significant value of each test, and an appreciation of the virtual impossibility of carrying out all these schedules at these rates at an extracontinental site. Continued continental, full-scale testing is necessary to ensure an acceptable rate of advancement."
>
> The Armed Forces. "Certain military effects experiments can only be conducted in the Pacific, and certain experiments to be meaningful can only be conducted on land masses typical of continents. For those experiments which can be conducted either in the Pacific or in Nevada, they can be conducted in Nevada more quickly, more easily, more accurately, and with economy of men, materiel, and dollars. Military assistance to the AEC in Nevada is less and much more easily provided. In the opinion of Department of Army, Nevada provides valuable troop indoctrination to large numbers of troops. Nevada provides a degree of operating flexibility not available in the Pacific, this affording major advantages to DOD in economy, wider participation by military commands, and ease of execution and support."
>
> Civilian Program. "For reasons of economy, convenience, and real estate the non-military Federal agencies can best accomplish their investigations in structural and functional design, materials and equipment, and biological effects at a continental test site. The FCDA has attested many times to the value of its test and demonstration programs in Nevada in stimulating public interest in national civil defense planning. FCDA considers it most important to carry out biomedical experiments, public demonstrations, structure and equipment testing, and training programs."

Why an Overseas Site Is Also Essential

Since larger yield weapons and devices may not be fired within the United States with the requisite degree of safety, continued use of the more isolated Pacific area is essential.

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It is not generally understood that devices and weapons tested in the Pacific have ranged in explosive energy released from around nominal kiloton levels to the multi-megaton level. Some devices or weapons which could be tested in Nevada are fired in the Pacific because of their relationship to subsequent tests in the series or because they require testing before a series will be ready in Nevada.

Costs in the Pacific are high in comparison with Nevada, but fully acceptable because of their value to weapons development. It has been estimated that a series such as Castle (Spring 1954) exceeded $100,000,000 in direct costs and required upwards of 30,000 persons if supporting elements are counted.

4. PLANNING AND CONDUCTING NEVADA TESTS

Origin of a Series

As weapons developmental work progresses, new ideas originate in the weapons laboratories, new requirements for weapons are posed by the military, or important new questions are asked as to design, efficiency or effects. As the various test projects accumulate, a series is scheduled tentatively for some future period, generally about two years away.

The winnowing out of test proposals for a specific series may begin a year in advance. Usually at about eight months in advance, plans are sufficiently firm to begin the procedures essential to starting construction and organization. At about five months, programming has progressed to the selection of an operating period and determination of total number of shots.

Each Shot Justified for Technical Necessity

Each Nevada shot must be justified as to its safety, but before then it must have been justified as to its importance to the nation. Only tests which are vital to national atomic programs, only those which contribute directly to the defense of this Nation and of the free world, are admissible.

The Nevada Test Site Planning Board examines each proposed nuclear test to determine whether it is technically necessary, whether it can be fired safely in Nevada or must be transferred to the Pacific, and whether the device and its associated experiments can be ready at the time required. If the test meets all the criteria it is incorporated into the schedule for a Nevada series.

Operating Considerations

Requirement for Technical Success. Each experimental device fired must be designed so the required diagnostic and effects information sought can be obtained with the minimum expenditure of fissionable materials. Requirements may include a new type of instrumentation to obtain diagnostic or effects data, and if so there must be assurance the data sought will be obtained.

Public Safety Requirement. No shot is scheduled in Nevada until a determination has been made that its firing will be acceptable under established criteria for offsite radioactive fallout. Because height of the detonation above ground level is a determining factor in nearby off-site fallout, a device that

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because of yield might not be acceptable if fired from a 300-foot tower might be scheduled atop a 500-foot tower or in a balloon cab. In a surface or shallow underground shot, a device of very limited yield is required so offsite fallout may be held within fully acceptable limits.

Placement of Devices. Some devices must be fired in a stable position, so precise measurements may be obtained by instruments registered on an exact point. Such devices are fired in Nevada on towers, ranging from 300 to 500 feet or higher in altitude. Where only fair precision is required, it has now been determined that a device may be fired in a balloon cab, where some motion may always be expected. Where only general positioning is required, an air drop may be scheduled. For some studies, surface and shallow underground positioning of shot devices may be called for. Elimination of all radioactive fallout through deep underground positioning of devices with small yields is another possible method.

Placement, to Avoid Contaminating Another Site. Sometimes a device must be detonated near the site of a future shot. Care must be taken that positioning of the device is such that winds at shot time will not place heavy concentrations of radioactive fallout on the future site so as to make it unusable.

Hours of Tests. Technical requirements determine whether a shot may be fired in daytime or requires darkness. If daylight is permissible, the usual hour is about 9:30 A.M., when wind usually is the calmest of the day. Experiments involving photography usually require darkness. For this reason the immediate pre-dawn hours are used, when there is sufficient darkness for experiments, followed shortly by daylight to facilitate post-shot operations. The wind also is usually calm at this period. A majority of shots in Nevada is fired before dawn.

Division of Real Estate, and of Air. The ground firing area around an air-drop zero point or a tower site is a fairly extensive piece of desert real estate, but with the use of tests for many purposes other than nuclear diagnostic experiments, there has developed a considerable problem of space. Complicating the problem is the fact that a majority of the experiments must be upwind from the detonation to avoid radioactive fallout contamination. To meet the problem the ground is divided into sectors such as a diagnostic sector, civil and military effects sectors, military materiel sector, and perhaps sectors for observation and maneuver by participating troops, and for a Civil Defense exercise.

The air above the Test Site must be divided as carefully. Well over 100 aircraft may be employed on a single test, with functions varying from dropping a bomb to tracking the radioactive cloud for hundreds of miles. With so many aircraft involved, schedules, orbits and abort procedures must be pre-planned to fractions of seconds.

Buildup in Laboratories and at the Site

Soon after the schedule is planned, the design and construction of specialized instrumentation begins in home installations, or elsewhere in educational or industrial installations. Preliminary laboratory calculations and experiments, and the design of the nuclear device itself, are pushed. Construction of technical facilities begins.

The final schedule of shots is proposed perhaps two months before the series, including the technical and public safety justifications for each shot, and Presidential approval obtained for the expenditure of fissionable materials.

Similar buildup progresses in many places. The Armed Forces plan their experiments, their troop training programs, the allocation of aircraft, and support services, these activities reaching out to a multitude of service laboratories and other installations, and to private contractors. FCDA likewise has to start early on arranging for and programming its experiments and training programs.

Obtaining the proper security clearance for participating personnel is itself a factor requiring a considerable lead time in scheduling.

The buildup of activity in Camp Mercury, and on Nevada Test Site begins months before the first shot with start of construction. As the series draws near, the construction activity decreases and the movement of military and civilian technicians and service personnel increases. Camp Desert Rock usually begins building up about two months before the series. Indian Springs Air Force Base has a somewhat later influx.

The Move to Nevada

At about minus one month scientists and technicians involved in early experiments move to Nevada to supervise final construction and equipment of their experiments. Final installation, wiring, and checking of instruments is supposed to be accomplished by minus two days, but may continue into the night before a shot.

The formal "operational period" of the series is usually approximately two or three weeks before the first shot. As of this date, the Test Manager takes over responsibility for all test operations in Nevada, retaining the responsibility until a week or two after the series ends.

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Pre-Shot Schedule and Considerations

Throughout the week immediately preceding any shot there is a progressive increase in activity. A series of tests is conducted to help technicians determine the readiness of their experiments. On some air burst tests a dry run drop of conventional high explosive may be held. If troops are to have a field maneuver, there will be a dry run maneuver about shot day minus two. Obviously, at some pre-test time the experimental device is assembled and positioned for firing.

An initial pre-shot, go no-go meeting is held about minus 48 hours. It determines the readiness of essential experiments, and results in preparation of a go no-go list to govern any last minute determination of whether to fire based on readiness or functioning of experiments. If there is probability that all key experiments will be ready, and if the preliminary, long range weather forecast is generally favorable, the specific shot operation gets under way.

Starting the operational sequence includes such items as advising distant air bases they may prepare to launch bombers participating in air crew training, or preparing in Washington to take off the next day with a flight of Congressional observers. Complications are many if the shot is subsequently postponed.

In the new series, a weather meeting will be held at 8:30 A.M. the day before the scheduled shot to determine if wind direction and stability as forecast seem to merit going ahead with shot preparations, and if so and if two shots are ready, which may be fired. Complications are obvious here also. One ready shot may involve heavy air activity, including long range aircraft which will be en route by this time. If that ready shot is set aside in favor of the second ready shot, which probably will not include the training projects, the aircraft then under way return to their home bases.

Final preparations go forward on all fronts if the morning weather meeting results in a favorable decision. These include clearing the technical area and Control Point of all non-authorized personnel and thereafter maintaining individual record checks to assure that all personnel are out by shot time. They include the issuance of advisory notices to the public and to health officers of adjacent states, and through CAA to commercial and private aircraft.

A formal evaluation meeting is held about 5 P. M. It includes a final readiness report on experiments, aircraft, and maneuver programs. It is essentially, however, a weather evaluation meeting. If weather promises to be right for technical experiments and onsite safety, the shot remains scheduled and the meeting progresses to consideration of weather and public health and safety. These evaluations and considerations remain the background for further evaluations at 11 P. M. and at 3 A. M., again related primarily to weather.

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Weather is Major Consideration. The single, major factor at zero hour or any time following zero hour with regard both to successful conduct of the technical operation and to blast and radiation fallout is weather.

The obtaining of scientific data, the operations of a bombing plane and scores of other aircraft, the direction and intensity of blast, the success of the troop operation, and the direction and intensity of radioactive fallout are all dependent on such factors as precipitation, cloud cover, temperature, temperature inversions, and wind directions and velocities.

It is essential that forecasters predict within small margins of error the direction and velocities of winds from ground surface upward to high altitudes. This is particularly difficult at ground surface in the mountain-surrounded basin used for a firing area where winds will circle the compass in a few moments.

To obtain comprehensive data, the U. S. Air Force Weather Service has established a weather unit at NTS, into which personnel of the U. S. Weather Bureau are integrated. It receives reports on hemispheric conditions and on more localized conditions. To further pinpoint conditions locally, a network of stations has been established in a complete ring around the Test Site. These are located at Kingman, Arizona; Baker and Edwards Air Force Base, California; St. George, Utah; and Indian Springs, Beatty, Tonopah, Reno, Austin, Lincoln Mine, Caliente and Overton, Nevada. Additionally, U. S. Weather Bureau stations at Bishop, California; Milford, Utah; and Ely, Las Vegas and Winnemucca, Nevada, will provide local information to the NTS weather unit as required. Other U. S. Weather Bureau and USAF stations will supply supplemental data on request.

New procedures have been adopted to facilitate more accurate forecasting of wind directions and velocities at zero hour and for several hours thereafter.

Weather conditions become progressively more important as shot hour approaches. An important factor is the final weather forecast, available at about minus one hour. It determines whether the test is to be fired.

Factors Affecting Last Minute Postponements

There are actually a considerable number of reasons for postponing a shot even after the evening evaluation meeting has decided to go ahead. Some, but not all, of these are discussed.

It is seldom that all of the multitude of experiments are satisfied on a shot -- because they were not ready, because of malfunctioning, or because of weather and shot effects. A shot is not fired,

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however, if a key experiment vital to the success of the shot will not be successful for any reason. Built-in safeguards automatically can stop a detonation if certain key experiments are not functioning at any second up to detonation. This occurred on a spring 1952 shot.

Any change in the forecast wind direction or velocity could result in a postponement. The formulae for predicting the intensity and location of significant fallout, on-site and off-site, must be matched to the varying weather forecasts throughout the night. The conservative guide to public radiation exposure -- 3.9 roentgens per series -- is determining in evaluating off-site fallout forecasts. If there are any indications that fallout from the present shot will cause exposure approaching that figure at any inhabited nearby point or if new fallout plus fallout from a previous shot in the series would bring the total near that figure, the shot will be postponed. It may be seen that as a series progresses, the segment of acceptable wind direction for a sensitive shot may grow constantly more restricted.

Related both to technical and safety considerations are the factors of cloud cover and atmospheric moisture. Clouds can prevent air operations, including key experiments. Any indication of significant precipitation over the test site or nearby region could result in a postponement. Precipitation at more than 200-300 miles is not a major factor, because by then radioactivity in the cloud has greatly decreased.

For an air drop, any malfunctioning of the drop aircraft would of course cause a postponement.

With heavy concentrations of aircraft above NTS, provision has necessarily been made for postponement if any craft is dangerously out of place for any reason. All flights are monitored by radars stationed within a few feet of the master control room at the Control Point. Only the reaction time of individuals involved determines the time required to stop a test in such a case.

Forecasts of the intensity and location of blast waves, based on weather forecasts, are made with each weather forecast. High explosive detonations fired shortly before the nuclear shot send out waves which are recorded on microbarographic equipment in nearby communities. A postponement could result if there was a firm forecast that high blast levels would be recorded in communities.

All individuals must be checked as having cleared the forward area. If a single person were unaccounted for, the shot probably would be delayed.

Pre-shot consideration is given to the flash effect from the viewpoint of issuing the necessary public warnings and taking such steps as asking state officials to establish roadblocks. The flash effect would now cause a postponement.

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Post-Shot Operations

On-site Monitoring. Soon after a detonation, monitors in the Test Director's organization move forward into the shot area to establish and mark fallout lines, such as the line where fallout may be measured at 10 roentgens or above. Guided by this survey, work crews then move into the area to recover instrumentation or materials of various kinds.

Monitors continue to measure and record the close-in, on-site fallout until its radioactivity decays to the point that it presents no hazard to personnel.

Cloud Sampling and Tracking. Soon after the detonation, Air Force cloud sampling crews begin flying through the radioactive cloud to obtain fission products so they may be analyzed in the AEC laboratories. As the cloud moves off the Test Site, Air Force cloud tracking planes follow and trace its path, usually for hundreds of miles, until it disperses into a mildly radioactive air mass.

Air Closure by CAA. From information supplied by the cloud tracking air crews to a Civil Aeronautics Administration official stationed at the Test Site, the CAA may order the closing of certain areas to air travel for specified times, until the radioactive cloud has dispersed and no longer constitutes a hazard.

Establishing the Fallout Pattern. Ground and air monitoring personnel take measurements of radiation off-site to determine the path of the cloud and to establish areas in which the greatest concentrations of off-site fallout are deposited.

Distant Monitoring. Several monitoring networks in the United States and abroad measure radioactive fallout from Nevada tests at points distant from the Test Site. Such fallout always is slight, and it has never been found in concentrations that would be significant to the health of any living thing.

5. TRAINING PROGRAMS, AND OTHER ACTIVITIES UTILIZING NTS AND OTHER NEARBY LOCATIONS

Civil Defense Training and Technical Programs

Participation by the Federal Civil Defense Administration in nuclear test activities began in 1951, the year in which the agency was established, and has continued in each test series at Nevada and in the Pacific.

The first civil defense participation in the fall of 1951 was limited to a brief course in radiological monitoring for a few FCDA staff members, and to a limited test of home shelters. In April 1952, FCDA took part in the first Nevada "open shot", to which uncleared observers and news media representatives were invited. The shot also was the first to be televised. Technical participation by FCDA was limited to a study project on radiological defense.

By the time of the spring 1953 series, FCDA had established a test operations staff and had developed programs to meet all agency objectives. FCDA technical programs in the "open shot" for that series included tests of typical American residences, home shelters, air zero locators, radiological defense instruments, drugs, structural components, and automobiles. Private industry joined in providing materials and objects to be submitted to the nuclear blast, and in evaluating results. More than 600 civil defense and news-media observers witnessed the detonation. In addition, a series of radiological defense courses for State and local radiological defense personnel was begun, and the training offered has proved valuable in developing leaders in this field. Many who have undergone training now are chief radiological defense officers of the civil defense system.

Major FCDA participation was involved in the spring 1955 series "open shot", including an extensive technical test program with much cooperation by private industry. Tests were conducted on various types of residences, shelters designed to withstand high blast pressures, emergency above-ground shelters, several kinds of emergency vehicles, railroad facilities, chemical and other storage facilities, radio and electronics equipment, public utility facilities, foodstuffs, fabrics, house trailers, commercial metal buildings, and other objects, materials, and instruments. More than 500 civil defense specialists took part in extensive exercises in mass feeding, communications, police, fire, sanitation, medical, welfare and other public services, Civil Air Patrol activities, and command and control techniques. A small group of the participants, including women, experienced the detonation in a trench in a forward position. More than 1,200 attended the program for indoctrination of civil defense officials. Despite delays that postponed the shot for 12 days from April 26 to May 5, about 500 observers stayed on and witnessed the detonation.

Military On-Site Training and Observation

Eighteen shots, beginning with the Fall 1951 series and continuing through the Spring 1955 series, have been used for maneuvers by Army or Marine troops, and for observation by military personnel. These have included various Exercise Desert Rock maneuvers, in which troops were stationed in trenches, tanks, or personnel carriers, and in which Marines also studied vertical envelopment by use of helicopters.

Experience has shown that the maneuvers have been of real value in the training and orientation of troops and commanders in the employment of essential personnel and equipment protection measures, and in the tactical employment of atomic weapons and ground forces under simulated atomic combat conditions, both offensive and defensive.

Exercises are directed by the Commander, Sixth U. S. Army, with headquarters at The Presidio, San Francisco.

Soldiers, Marines, and their officers have observed detonations from trenches and foxholes at distances of 7,000 to less than 2,500 yards, depending on the nature of the exercise, the type of detonation, and other factors.

Air Crew Training and Indoctrination

Training of air crews and general indoctrination have been a part of each test series in Nevada. Coordination of the program is achieved through the joint efforts of the Armed Forces Special Weapons Project and the U. S. Air Force Special Weapons Center.

The 1955 series included training programs for the Strategic and Tactical Air Commands, other Air Force Commands, and Navy and Marine air units. Training and support missions have included reconnaisance, photography, cloud tracking, weapons delivery, fighter escort, and drone operations. About 2,600 sorties originated at numerous bases throughout the United States and at least one base outside the continent in the 1955 program. Some 25 basic types of aircraft were used.

Control of all aircraft was accomplished through an Air Control Center at the Test Site, operated by AFSWC personnel integrated into the Test Organization. Facilities for visiting aircraft and for official observers were operated at Indian Springs Air Force Base.

Public Health Service Training

Active and reserve officers of the U. S. Public Health Service first participated in the off-site radiation monitoring program of the Fall 1951 series in Nevada, and have been active in each series since. While their duties have been primarily in support of test operations, their work has been considered also active duty training for any future radiation emergency. During the 1955 series a Mercury laboratory and all off-site radiation monitoring positions were staffed by USPHS personnel. In that series the monitors were assigned permanently to key communities surrounding the Test Site.

Other Programs at Nevada Test Site and Nearby

The Safety Experiment Program. Since November, 1955, experiments have been conducted from time to time at the Nevada Test Site to determine the safety of nuclear weapons in case of accidents during handling or storage. Two such experiments were conducted in November, 1955; another in January, 1956; and a fourth was scheduled in late April, 1957. Several other such tests are being conducted during the summer of 1957 series at times when the test site is not being used for full-scale nuclear detonations.

Livermore High Explosive Tests. Since 1954, the University of California Radiation Laboratory at Livermore has conducted small scale high explosive tests periodically within the Nevada Test Site. Use of the Nevada site for such experiments is necessary because of lack of an isolated area within the boundaries of the Laboratory proper at Livermore.

New Technical Area. Preliminary steps in the development of a new technical area for AEC studies have been announced. The new area adjoins the original Nevada Test Site, and will be used for ground testing of nuclear rocket propulsion devices after roads, water wells and structures have been completed. Completion of construction work now is expected late in 1958.

Tonopah Ballistics Range. First operations were conducted in February, 1957, at the AEC's Tonopah Ballistics Range, located southeast of Tonopah, Nevada, and northwest of the Nevada Test Site in a 624 square mile area acquired from the U. S. Air Force on a temporary basis. At the range, air drops are conducted using inert weapon shapes. The Sandia Corporation, which operates the AEC's Sandia Laboratory for weapons development at Albuquerque, New Mexico, operates the Tonopah Range for the Commission, and drop planes are from the USAF Special Weapons Center, Kirtland Air Force Base, Albuquerque. It is planned that the range will be used for about three years, after which it may be supplanted by a ballistics range the Air Force plans to build, for Department of Defense-Atomic Energy Commission joint use, in northwestern Arizona.

Watertown Project. Construction began in 1955 on a small facility at Groom Dry Lake adjacent to the northeast corner of the Nevada Test Site, and within the boundaries of the Las Vegas Bombing and Gunnery Range. Construction included dormitories, equipment, buildings and a small air strip. Since that time, the National Advisory Committee for Aeronautics has announced that U-2 jet aircraft with special characteristics for flight at exceptionally high altitudes have been flown from the Watertown strip with logistical and technical support by the Air Weather Service of the U. S. Air Force to make weather observations at heights that cannot be attained by most aircraft.

Other Projects at NTS. From time to time, the Nevada Test Site is the scene of studies or tests of various kinds, because of its isolation or because of the history of previous nuclear detonations there. For example in 1955 the Federal Civil Defense Administration conducted its "Operation ARME", an aerial and ground monitoring exercise for FCDA personnel, in Yucca Flat where nuclear detonations had occurred earlier in the year. In April, 1957, high explosives were set off inside a prototype process structure in a remote area of the Test Site to test the explosive-containing characteristics of the structure. Additionally, the Test Site is used from time to time for other similar activities connected with the programs of the AEC, the DOD, the FCDA, or other agencies.

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6. THE NEVADA TEST ORGANIZATION

All tests in Nevada are conducted by the Nevada Test Organization, which is made up of representatives of the Atomic Energy Commission, the Department of Defense, the Federal Civil Defense Administration, other government agencies, government contractors, research and educational institutions, and private industrial firms. (See charts at the back of this booklet.)

An AEC Test Manager has had over-all field management of each series conducted in Nevada. His task is to plan operations, to coordinate the activities of all the units within the Test Organization, to exercise operational control at the Test Site, and to prepare and execute operations as scheduled. His is the final decision as to whether operational conditions will permit a shot to be fired, or whether a postponement is required.

Since the fall of 1951, a Deputy for Military Matters has served under the Test Manager. He represents the Commander, Field Command, Armed Forces Special Weapons Project, and provides staff assistance to the Test Manager on matters involving Department of Defense participation and support. He also performs liaison between AEC and DOD agencies on policy and operational matters, and is responsible for military administrative matters such as management of military property and funds.

Prior to 1957, the Test Director for each series had been a representative of the Los Alamos Scientific Laboratory. For the Summer 1957 series, a staff member of the University of California Radiation Laboratory at Livermore was appointed to the position, reflecting the growing participation by the Livermore laboratory in test operations. The Test Director is responsible for over-all coordination and scientific support for the entire scientific test program; for planning, coordinating and conducting the tests of experimental weapons and devices; and for positioning, arming and detonating the test devices.

Other officials of the Test Organization are responsible for various functions such as logistical support, weather prediction, fallout prediction, blast prediction, air support, public information, radiation safety operations, safety and fire protection, and so on.

An organization chart is included toward the back of this booklet.

The background of major participating organizations is given elsewhere.

U. S. Atomic Energy Commission Albuquerque Operations is a U. S. Atomic Energy Commission field organization for the research, development, testing, production and storage of atomic weapons. K. F. Hertford is Manager of Albuquerque Operations, and maintains his headquarters in the Albuquerque Operations Office (ALOO) in Albuquerque, New Mexico.

In addition to the ALOO headquarters, Albuquerque Operations has eight area offices and three branch offices supervising the operation by contractors of a complex of laboratories, test sites, and industrial facilities reaching from the Atlantic seaboard to Eniwetok Atoll in the far Pacific.

The test sites administered by Albuquerque Operations include the Eniwetok Proving Ground in the Marshall Islands and the Nevada Test Site.

Los Alamos Scientific Laboratory (LASL) was established at Los Alamos, New Mexico, early in 1943 for the specific purpose of developing an atomic bomb. Los Alamos scientists supervised the test detonation in July, 1945, at the Trinity site in New Mexico of the world's first nuclear weapon. The Laboratory's current weapons assignment essentially is to conceive, test and develop the nuclear components of atomic weapons. Its Director is Dr. Norris L. Bradbury. It is operated by the University of California.

University of California Radiation Laboratory (Livermore branch) was established as a second AEC weapons laboratory at Livermore, California, in 1952. The Livermore laboratory's responsibilities are essentially parallel to those of the Los Alamos laboratory. Livermore weapon designs first were tested in Nevada in 1953, and they have been tested in each continental and Pacific series since. The contract under which the University of California Radiation Laboratory performs work for the AEC is administered by the Commission's San Francisco Operations Office. Director of the Livermore facility of the UCRL is Dr. Herbert L. York.

Sandia Laboratory at Albuquerque, New Mexico, is the AEC's other weapons laboratory. It was established in 1946 as a branch of the Los Alamos Scientific Laboratory, but in 1949 it assumed its present identity as a full-fledged weapons research institution, and since then has been operated by the Sandia Corporation, a non-profit subsidiary of Western Electric. Sandia Laboratory's role is to conceive, design, test and develop the non-nuclear phases of atomic weapons, and to do other work in related fields. In 1956 a Livermore Branch of the Laboratory was established to provide closer support to developmental work of the UCRL Livermore facility. Sandia Corporation also operates ballistic test facilities for the AEC at Salton Sea Test Base, California, and at the Tonopah Ballistics Range near Tonopah, Nevada. President of the Sandia Corporation is James W. McRae.

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Armed Forces Special Weapons Project (AFSWP), composed of personnel of the three Armed Services, was activated January 1, 1947, to assume certain residual functions of the Manhattan Engineer District and to assure continuity of technical military interest in atomic weapons.

AFSWP is commanded by Major General Alvin R. Luedecke, U. S. Air Force. Brigadier General Charles E. Hoy, U. S. Army, and Rear Admiral Horacio Rivero, U. S. Navy are deputies. AFSWP Headquarters is in Washington, D. C.

Field Command, AFSWP, located at Sandia Base, Albuquerque, is commanded by Rear Admiral Frank O'Beirne, U. S. Navy.

The broad mission of AFSWP is planning specified technical services to the Army, Navy, Air Force, and the Marine Corps in the military application of atomic energy, with Field Command providing liaison with AEC and its laboratories in the development of nuclear weapons; planning and supervising the conduct of weapons effects tests, and providing atomic weapons training to military personnel.

Early in the program for testing nuclear devices and weapons, AFSWP was charged with the responsibility for planning, and integrating with the AEC, military participation in full-scale tests. After the Nevada Site was activated, the planning responsibility was broadened to include conducting experimental programs of primary concern to the Armed Forces, and coordinating other phases of military participation and of assistance to the AEC.

Continental test responsibilities assigned to Field Command, AFSWP, are handled by its Weapons Effects Test Group, directed by Colonel Hershell E. Parsons, U. S. Air Force.

Air Force Special Weapons Center (AFSWC) at Kirtland Air Force Base, Albuquerque, became a part of the Air Research and Development Command on April 1, 1952. The Center is commanded by Brigadier General William M. Canterbury.

Research work done at AFSWC principally is of an applied type aimed at solutions to particular problems. The Center's principal day to day job, which involves developmental and test activities, is the proper marriage of nuclear warheads to Air Force weapons, and nuclear weapons to aircraft. This work involves harmonizing the views of aircraft and weapons manufacturers with Air Force operational requirements.

The Center works in close cooperation with the Armed Forces Special Weapons Project, AEC, Sandia Corporation, and aircraft manufacturers, as well as with other Air Force organizations in carrying out its broad role of assuring that vital nuclear weapons research and development receive proper emphasis in the accomplishment of the Air Force mission.

As field headquarters for Air Force nuclear resaerch and development, AFSWC has provided air support for ten previous Nevada and Pacific test series. The Center's air support unit is the 4950th Test Group (Nuclear), commanded by Colonel Paul B. Wignall. The 4950th was activated in September, 1956, to plan for and accomplish the portions of testing programs in Nevada and the Pacific for which AFSWC is responsible.

One squadron of the 4950th, the 4926th Test Squadron (Sampling), has the task of gathering samples from radioactive clouds after test detonations. Major Malcom S. Bounds commands the squadron. Another 4950th unit, the 4935th Air Base Squadron, operates Indian Springs Air Force Base throughout the year.

AEC Support Contractors. In keeping with its policy nationally, the Atomic Energy Commission utilizes private contractors for maintenance, operation, and construction (including military and FCDA construction) at the Nevada Test Site. Personnel of the AEC's Las Vegas Office administer all housekeeping, construction and service activity, but performance is by contractors.

Reynolds Electrical & Engineering Company is a principal AEC support contractor for the Test Site, performing community operation, housing, feeding, maintenance, minor construction, and scientific structures support services.

Holmes & Narver, Inc., performs architect-engineer services for the Test Site. The firm, with home offices in Los Angeles, is the principal support contractor for the Commission's Eniwetok Proving Ground in the Pacific.

Federal Services, Inc., provides security and other guard services for the Test Site and for Las Vegas AEC offices.

Pacific Telephone and Telegraph Company provides communication facilities and service as needed.

Numerous other contractors selected on the basis of lump-sum competitive bids perform construction of test towers, structures and other facilities at the Test Site.

7. WHERE NEVADA TESTS ARE CONDUCTED

Location and Geography

The southern edge of the Nevada Test Site is approximately 65 miles northwest of Las Vegas. The original Test Site, the part in which nuclear tests are conducted, covers an area of approximately 415,000 acres, roughly 16 x 40 miles, extending longest north and south. On two sides -- east and north -- it adjoins the U. S. Air Force's Las Vegas Bombing and Gunnery Range of which it was originally a part.

The terrain is typical of the section of Nevada, including ranges of hills and mountain peaks, and desert valleys with drainage into dry lake beds. The altitude varies from 3075 to 4050 feet above sea level.

South of NTS, roughly between it and Las Vegas are the Spring Mountains, which include Charleston Peak and Angel's Peak from which many Civil Defense and news groups have observed past detonations.

Colorful names develop from reading a map clockwise around NTS: Specter Range, Rock Valley, Skull Mountain, Jackass Flats, Lookout Peak, the intriguing "Barren Spot", Mine Mountain, Shoshone Mountains, Eleana Range, Papoose Range, Emigrant Valley, Timpahute Range, Ranger Mountains, Spotted Range, and Sheep Mountains.

Additions to the Original Site

The Test Site has a four-section protuberance on the south which contains the AEC's Camp Mercury, but not the Army's Camp Desert Rock which is two miles south of Mercury.

During 1955, construction of a small facility at Watertown, in the Groom Lake area at the northeast corner of the Test Site, was announced. The area has been joined to the air closure space over the Test Site in which unauthorized aircraft may not fly, but it has not been made a part of the Test Site.

During 1956, annexation of a 12.2 x 39.6 mile area to the Test Site was announced. The added land was obtained from the Air Force by the AEC as the site of a new technical area in which ground tests will be conducted on nuclear propulsion devices for guided missles. Nuclear detonations will not be conducted in the new area, which lies to the west of the original Test Site and formerly was a part of the Las Vegas Bombing and Gunnery Range.

A new area immediately north of the Nevada Test Site but within the boundaries of the Las Vegas Bombing and Gunnery Range was

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developed for the safety experiment which was conducted April 24, 1957. The area, 10 x 16 miles and located about eight miles west of the Groom Mine, was withdrawn from grazing before the first ready date of the experiment, April 10.

Contract and Construction Data

From activation on January 1, 1951, through January 1, 1957, the total cost to the AEC of permanent construction at NTS has been $13,546,829. This does not include the cost of test structures, test equipment, or other facilities in forward firing areas, which are considered either expendable or, at best, only semi-permanent. The total does not include quonsets, hutments, warehouses and other facilities and equipment, mainly of a non-permanent nature, supplied by the Department of Defense.

It is probable that the total United States investment at NTS in permanent, semi-permanent, and presently reusable structures, equipment and other facilities approximates $23,000,000.

Supporting Installations

NTS has two general areas: the Camp Mercury area and the forward or technical area. The latter is further divided by operating personnel into the Control Point area, the Yucca Basin area, and the Frenchman Flat area.

Camp Mercury is five miles north of Highway 95. The official name -- it has had a post office since March 1, 1952 -- and one that is becoming more commonly used as the years pass, is "Mercury, Nye County, Nevada." The camp provides office space and living quarters for civilian and military test organization personnel in both temporary and permanent quarters. Also provided are utilities, warehouses, mess halls, recreation facilities, motor pool, laboratory facilities, and administrative offices. New construction since the 1955 series, including 14 men's and two women's dormitories, has helped relieve but has not removed the overcrowding which exists just before and during test series. Maximum population at the camp in 1955 was 2700. It is estimated that 3500 was the peak population for the 1957 series, and trailers are being used extensively.

Camp Desert Rock is an Army installation approximately 63 miles northwest of Las Vegas, adjacent to the AEC's Camp Mercury and just outside the boundaries of the Nevada Test Site.

It is largely a trailer and tent camp around a nucleus of semi-permanent structures, contracting to less than 100 personnel during non-test periods and expanding, in the 1955 series, to

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slightly less than 2,500 men who made up the station complement for housekeeping and similar duties, and to about 3,500 other men at any one time. Camp Desert Rock housed about 9,000 men from the military services during the 1955 series. Some saw a single shot and departed for their home stations, and others stayed throughout the series.

The Camp Commander is the Deputy Director of Exercise Desert Rock, Brigadier General Walter A. Jensen, Commanding General of Camp Irwin, California.

The camp is an installation of the Sixth U. S. Army which has its headquarters at The Presidio, San Francisco, California, and is commanded by Lieutenant General Robert N. Young. General Young is Director of Exercise Desert Rock.

Indian Springs Air Force Base is located about 41 miles northwest of Las Vegas and 24 miles southeast of Mercury, on about 1,400 acres of land formerly within the Las Vegas Bombing and Gunnery Range.

The base formerly was a satellite field for Nellis Air Force Base at Las Vegas. In July 1952 the base was transferred from the Air Training Command to the Air Research and Development Command to be operated by the Air Force Special Weapons Center which is headquartered at Kirtland Air Force Base, Albuquerque.

Indian Springs is the base of operations from which many specially-instrumented aircraft are sent aloft preceding and following each nuclear detonation to collect scientific data.

Major Harry Elmendorf commands the Base. The 4935th Air Base Squadron is the service unit stationed at the Base.

Technical Areas Within NTS

The forward, or technical, area of the Nevada Test Site is divided generally into the Control Point area, the Yucca Basin area, and the Frenchman Flat area.

The Control Point is a complex of permanent facilities approximately 20 miles north of Mercury. It is on the crest of Yucca Pass which connects Frenchman Flat and Yucca Basin, permitting vision into both general areas.

Frenchman Flat is in the next dry lake basin north of Mercury, with a pass in between. All the shots in the first series were fired there. It has been used only occasionally since, usually for the more extensive military effects tests.

Yucca Basin is a valley roughly 10 X 20 miles extending northward from the Control Point. It has considerable relatively level land, and an extensive dry lake on which an air landing strip has been laid out. Near the Control Point end of the basin are News Nob and other official observer sites. Twelve firing sites have been laid out in the basin. Developed sites may have instrumentation towers, underground instrumentation bunkers, other types of recording equipment and structures, and such items as rocket launchers and mortars used to put up trails or puffs of smoke useful in making measurements. Areas have been developed for air drops and for tower, surface, tunnel, and balloon placements. Some areas are suitable for more than one such type of placement.

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8. TECHNICAL FACILITIES AND INSTRUMENTATION

Purpose of Technical Facilities

The scientific objective in nuclear tests is to make objective and quantitative measurements of the physical phenomena involved so as to compare them with previous performance, to verify theoretical predictions, and to understand more fully the phenomena involved.

Generally the various measurements are divided into two categories, those in which quantities intrinsic to the device itself are measured, and those in which the effects of the device upon its environment are determined. The diagnostic measurements are immediately related to the problems of weapon development.

The list of quantities or effects which may be measured for diagnostic purposes may include gamma rays, neutrons, visible light, and thermal or other electromagnetic radiation. Effects measurements may include blast pressures, wind loadings, thermal effects as on materials, radioactivity, visible light and gamma rays as in their effect on animals.

Technical Structures and Instruments

In view of the varied interests represented in almost every test, the technical facilities at NTS -- and particularly those which are used again and again -- must be flexible.

Air drop targets are a surfaced cross, with concentric circles marked, and lighted for pre-dawn shots. They are surrounded by structures and instruments much as those described below.

Test towers are of various heights and strengths, depending upon the conditions of the test. They have in the past most frequently been of 300 and 500 feet, although lower towers have been used.

The strength is varied according to the weight and size of equipment the tower will support. They are designed to use as little material as possible, partly for economy but primarily to reduce the quantity of vaporized material which will contribute to the radioactive cloud and fallout.

Unvaporized pieces of towers on some shots have been thrown for considerable distances and constitute a hazard affecting the placement of maneuver personnel.

A device to be tested, detection equipment, and other acessories are contained in a room at the top of the tower, called the "tower cab." There is usually an elevator, which is removed prior to the detonation.

There are towers for other purposes, such as collimators, photography, and television.

Balloon winches and winch shelters are installed generally in areas that have bunkers and other installations used also in tower shots. Each balloon station has three winches installed in shelters to shield machinery from the nuclear detonation. Cables from the winches are used to raise and lower the balloons as necessary. A fourth holding cable is under the balloon, leading straight to the ground surface.

Instrumentation and Structures. Through the years improvements in the methods of testing nuclear devices have been as marked as the improvements in weapons themselves, This is particularly true of instrumentation and electronics engineering. In developing faster, more precise instruments the test organization has turned to trained manpower throughout industry, government, and the universities. Developments originating in this program have, as a by-product, contributed to the general development of instrumentation applicable to many other fields.

The experiments require instrumentation ranging from very costly and complex electronics systems housed in monolithic, heavily-shielded underground recording shelters, to inexpensive and simple film badges and indenter gauges. There are cameras with framing rates in ranges from a few frames a minute up to 8,000,000 a second. There are neutron detectors, thermal instruments, and blast gauges.

Each firing area is equipped with several permanent instrument stations, in addition to a wide variety of temporary stations and test structures used for one shot only, or at most for a single series. Most stations, either permanent or temporary, receive power, telephone communications and timing signals from permanent local distribution points within various firing areas. A few outlying stations rely on portable generators and radio for these services.

Underground Instrumentation Bunkers. Coaxial cables extend from the cab to an underground instrumentation bunker. They run direct from cab to bunker by the shortest practical line, rather than down the tower and across the surface of the ground, so signals will reach the bunker before radiation can shortcut the cables and before the cables are themselves disintegrated. In the ground, cables are laid in transite conduit, so that individual cables which may become defective with use can easily be pulled out of the conduits and be replaced.

In some tests collimator systems have been used to record gamma or neutron radiation. Exact positioning is a necessity. There is a declining height system of towers and of concrete walls extending from the tower to an underground recording station. Each tower or wall supports a heavy mass with several holes in it. These holes are aligned so that there is direct line-of-sight from the atomic device to the underground recording equipment. The holes provide clear paths for gamma radiation or neutrons, with heavy shields insuring that gamma or neutrons from regions outside the line of sight will not reach the detectors underground.

Large underground bunkers or blockhouses for recording instruments have been built close to ground zero in several firing areas. These massive concrete and steel units are topped with a thick mound of earth, the surface of which is stabilized by an asphalt coating. Depending on their nature and the type of equipment used, these blockhouses cost from $100,000 to $600,000. They are built to withstand all effects of detonations. Their initial cost is high, but they may be used for many test operations.

The underground bunkers not only protect the instruments against blast, but also against radiation. Without shielding, the intense radiation fields which accompany the detonation would immediately fog all film, ionize the gasses in the electronic tubes and cause other severe damage putting the equipment out of order.

Underground bunkers at NTS are used to record blast, heat, neutron or gamma radiation, or for taking photographs, but they vary considerably in design.

While data from an experiment may be recorded in a few millionths of a second, many months of work go into constructing and equipping a bunker. The scientists responsible for setting up the equipment work for months in home laboratories and fabricating plants before working the clock around for weeks or months to install it in the bunker. Working with them at NTS are construction and electrical contractor personnel.

Final calibration of instruments, checking circuits, testing of signal strengths, time signal relays, and electrical power behavior are performed during the week immediately preceding a detonation.

Prior to the shot, hundreds of switches for the recording instruments are pre-set, then the bunker is evacuated with no person inside at shot time. Heavy lead-lined doors like the bulkhead doors of a large warship are closed and sealed. When the massive outer door swings shut the bunker is ready to receive and record the data from the assortment of instruments above ground -- instruments which may be vaporized in the instant of detonation.

On a fixed schedule prior to the shot, the timing mechanism in the control room back in Yucca Pass sets in motion the whole mechanism at the tower, on the ground, and in block houses and bunkers in the area.

Frequently the most useful measurements are those of what takes place within the detonation itself. Since the measurements must be made in millionths of seconds -- or less--- the resolving time of equipment must be incredibly short. To catch the immediate early phenomena of the detonation, the detectors and gauges must be placed on the tower in close proximity to the unit being tested. This, of course, means that the detectors are almost instantly vaporized, but in the millionths of a second before they are destroyed, they transmit the all-important signal to the recording devices in the bunker.

Instrumentation in the bunker consists mostly of power supplies, amplifiers, oscilloscopes, cameras, and other recording devices. Large coaxial cables carry the signal to the recording machines from the gauges and indicators outside.

The electronic recording circuits respond extremely rapidly. They can be made to operate in a few hundred-millionths (0.00000001) seconds. A great deal of light is required to write on photographic film in such a limited time. Unless special precautions are taken, this light would badly fog the film during the many minutes the instrument is waiting for its signal to be given. To solve this dilemma the electron beam is reduced in intensity and deflected off the screen prior to zero time. At the last possible instant it is necessary to raise this intensity to its required value. By an ingenious arrangement, the coaxial cable is tapped so that the signal itself can trigger an intensifier. The signal, however, passes through a greater length of cable and hence appears at the scope to be recorded a micro-second or so after the intensity has been increased.

The record is of very short duration. Fortunately, however, the fluorescent oscilloscope screen retains the image briefly after the electron beam has swept across. The persistence of the image, analagous to a modern television tube where no flicker is discernible to the eye, is sufficient to permit permanent recording on the photo film.

These films are the raw data from which the results of the experiment are interpreted.

After the shot, re-entry to the building and recovery of the data is made as soon as radiological safety precautions permit. This is normally within a few hours after the blast.

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The Control Point

The Control Point in Yucca Pass is the brain -- the nerve center -- of every test operation at NTS.

From it radiate the myriad communication lines and channels required for receiving information and transmitting orders to control a complex operation. There are long distance telephone lines and teletype circuits to receive information from and provide information to Washington, Los Alamos, Albuquerque, Berkeley and elsewhere. Into it feeds weather information from a Class A Weather Center in Mercury which receives information from all over the world through Air Weather Service networks, as well as up-to-the-minute information on local conditions through stations manned specifically for these operations.

Beyond this control of the operation there is also the control of the many experiments themselves. There are filaments to be turned on, power must be applied to many circuits, camera shutters must be opened and closed at exact moments, ultra fast as well as normal movie cameras must be started, blast proof doors must be secured, some signal lights must be turned on and others turned off. In static tests the nuclear device itself must be armed and fired. These and hundreds of similar details must be taken care of without fail in proper order and at pre-determined times so that the desired information can be obtained.

This control of experiments is provided by a device known as a "sequence timer" located in the control room. The device sends out electric signals which activate relays to perform the above tasks; it starts clocks to measure the times at which these signals are transmitted; it measures the time of the detonation; and it even starts itself -- in case of an air drop -- when the bomb leaves the dropping aircraft.

All instruments closer than seven miles to a shot are remotely operated. A few instruments are completely self-contained and are activated by light or other characteristics from the nuclear explosion, but most are put into operation by time signals from the Control Room. The early time signals -- from minus an hour to five minutes -- are used primarily for such things as turning on power for electrical and other recording equipment, opening protective blinds, and closing air-conditioning vents. Later signals, coming within a few seconds of zero time, are used to start high speed recording equipment and other test instruments which are carefully programmed and require very accurate timing relative to detonation time. For instance, at minus five seconds a series of rockets may be fired to set up rocket trails for observation by high speed cameras.

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A complex instrument panel in the Control Room reflects these intricate operations. The first section of the panel is used only for air bursts, receiving signals from the bomber indicating release and, seconds later, recording the detonation. The second and third sections contain the frequency control equipment for the motor-generator set which supplies power to the timing equipment, with voltage recorders, connected to various points in the target area -- thus assuring accurate timing -- and records for wind velocity and direction. In order to activate test equipment at the exact time, very precise control of the frequency for the timer is required.

New Instrumentation

Several instruments of new or improved types have been developed by Edgerton, Germeshausen & Grier, Inc., a prime contractor to the Atomic Energy Commission, for recording and measuring effects of the detonations during the 1957 series.

Measurement of events that take place within ten billionths of a second now are possible.

One new instrument that measures within such a time range is an electronic "streak" camera that was given a trial in the 1956 Pacific test series and is being used by EG&G to register effects in this year's Nevada nuclear tests.

In the camera, the light image is received by an electronic device that translates it into intensified electrical impulses that are beamed to a phosphorescent screen in the back of the camera and then recorded on a stationary film. Each individual image is recorded in a different position on the film by means of a scanning device so the film has a "streak" of consecutive pictures on it, explaining the descriptive name of the camera.

The extremely brief duration of the event pictured is made possible by the speed of the scanning mechanism.

In another development, EG&G is attempting, with newly developed equipment, to photograph shock waves as they are reflected from objects and from people. Comparatively weak shock waves are photographed as they are reflected from persons at a safe distance from the detonation, as a study into the effects of blast on human bodies.

The reflected shock waves cause visible distortions of light similar to those created by a mirage of hot air, and special techniques have been worked out for obtaining photographs of the reflected waves.

The same principle is applied in photographing shock waves of materials and designs for shielding instruments, such as cameras, from the blast of nuclear detonations. Information on the way shock waves are reflected or absorbed by shielding materials and shapes may lead to better protection of valuable instruments used to record effects of detonations.

An improved high-speed cathode ray oscilloscope for measuring gamma radiation in the early stages of a detonation has been developed by EG&G engineers and is being used for the first time in Operation Plumbbob. The instrument is like those used in past series except that it can record reactions within the range of less than a ten billionth of a second.

The oscilloscope is positioned in an instrumentation bunker where it can be shielded from the effects of the detonation. It consists of a long narrow tube working on the same principle as those used in television sets.

The instrument receives its signal from a detector which may be located within a few feet of the nuclear device, and which relays its signal electrically by cable to the oscilloscope. Even though the detector is destroyed by the detonation, the signal already will have been transmitted and will reach the recording instrument.

The newly improved oscilloscope can record events of extremely brief duration because it has greater capacity to intensify a weak electrical signal and cause it to flash brightly across the screen. There it is photographed by a pre-set camera with open shutter so a permanent record can be obtained.

EG&G engineers and technicians also have developed for use in balloon detonations in the series a light-weight firing rack, or "zero rack," which is a modification of a device that has been used in past series for tower shots. The rack, somewhat similar to an electrical switchboard in purpose, contains electrical controls and connections necessary for furnishing power for initiating associated experiments and for detonating the nuclear device.

Racks used on towers contain heavy batteries for power, and weigh something like 300 pounds. The newly developed rack has no batteries, and through use of design changes such as smaller components and lighter metals, its total weight has been reduced to about 45 pounds.

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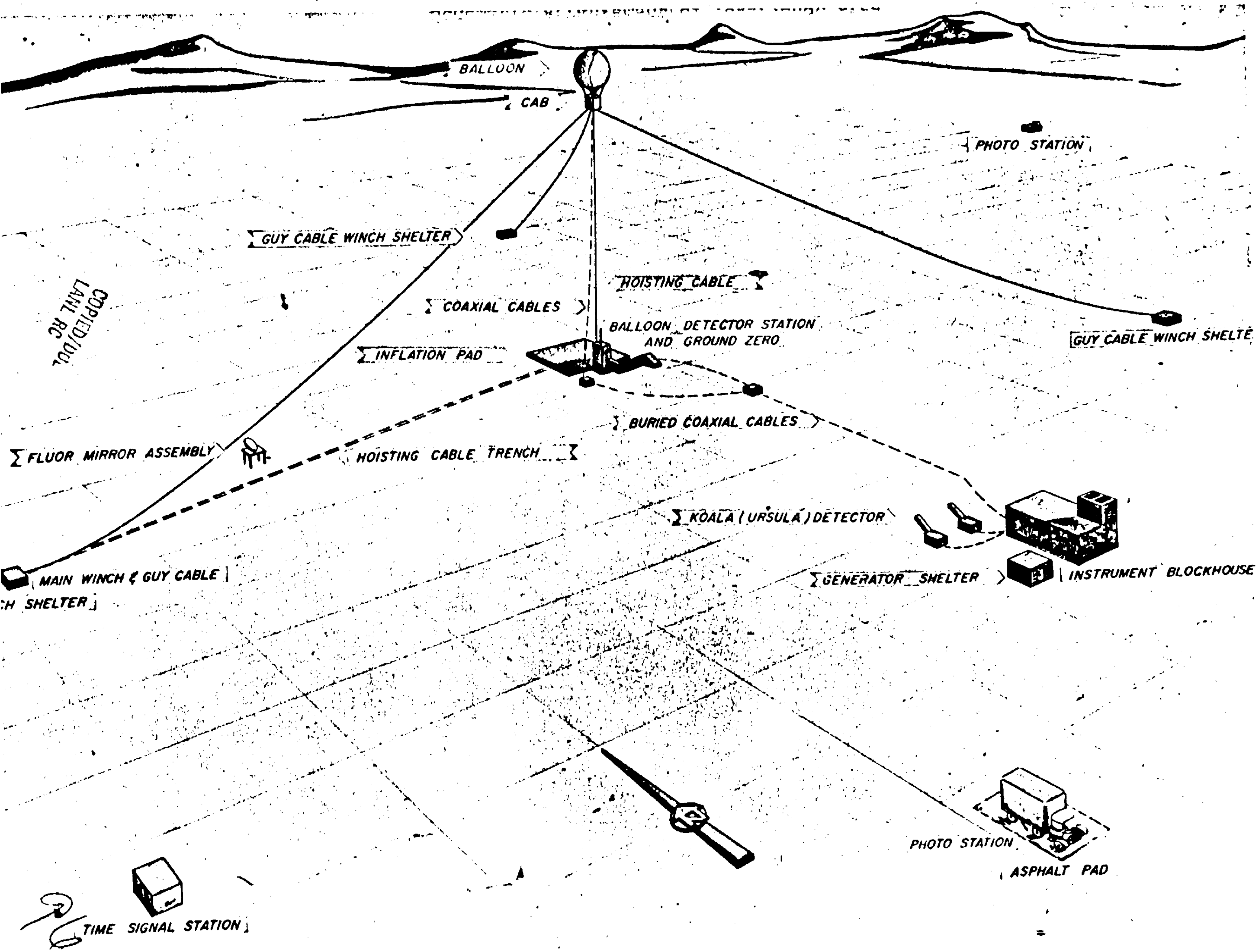
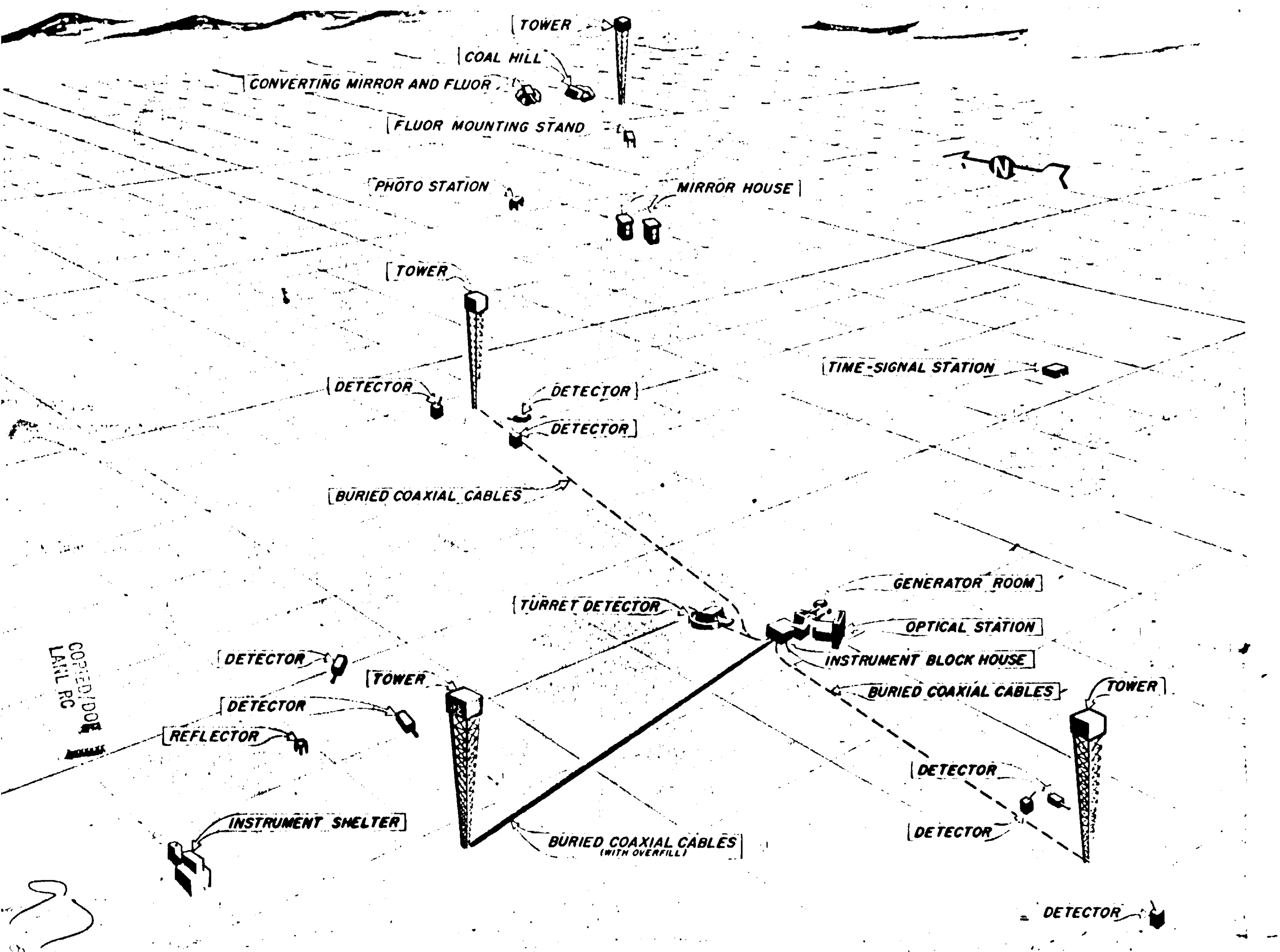


Schematic Arrangement of Balloon Shot Area



TOWER
COAL HILL
CONVERTING MIRROR AND FLUOR
FLUOR MOUNTING STAND
PHOTO STATION
MIRROR HOUSE
N
TOWER
TIME-SIGNAL STATION
DETECTOR
DETECTOR
DETECTOR
BURIED COAXIAL CABLES
GENERATOR ROOM
TURRET DETECTOR
OPTICAL STATION
INSTRUMENT BLOCK HOUSE
BURIED COAXIAL CABLES
DETECTOR
TOWER
TOWER
DETECTOR
REFLECTOR
DETECTOR
DETECTOR
INSTRUMENT SHELTER
BURIED COAXIAL CABLES (WITH OVERFILL)
DETECTOR
DETECTOR

PART II

9. THE 1957 NEVADA TEST SERIES

July 15, 1957

The Purpose

In announcing plans for conducting a 1957 Test Series at the Nevada Test Site (January 25, 1957) the Atomic Energy Commission declared:

"The program of tests is aimed to attain new knowledge important to the defense of the United States and the Free World, which must be maintained pending ultimate attainment of international agreement on safeguarded disarmament. The development of weapons for defense against attack is a major objective. Studies of weapons effects will also be continued in order to improve military and civil defense against nuclear attack."

Extent of Program

More detonations have been scheduled for the 1957 series (known as Operation Plumbbob) than for any previous Nevada series. The exact number is not yet known and will depend on test results. It is possible that shots will be deleted or added because of the results of experiments previously conducted during the series.

The following total of shots will have been held or announced by the date of this revision: seven tower shots to which newsmen are being admitted, plus two additional tower shots; two balloon suspension shots to which newsmen are being admitted, plus three already fired; an air-to-air rocket test; and an underground tunnel placement. These add up to 16, which is more than the total of 14 shots fired in the spring 1955 series.

Each experimental shot ordinarily includes five or more key experiments and perhaps up to 75 or 80 experiments. The maximum number of experiments to be connected with the sequence timer in any one test in this series is 66. A shot is fired only if there is good assurance that key experiments will obtain the desired data.

The designed yield of the Hood shot on July 5, 1957, exceeded the designed yield of the final detonation of the spring 1953 series, which was the largest in explosive force previously fired in Nevada. Like the final 1953 burst which was an air drop detonated well above ground level, the Hood shot, which was fired at 1500 feet suspended from a balloon, resulted only in very low level fallout in the region near the Nevada Test Site.

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None of the shots in the summer 1957 series is expected to produce as much fallout on nearby regions as did some of the shots in the 1955 Teapot series. The total fallout on the region around the test site from all detonations in the 1957 series is expected to be less than that for any Nevada test series since 1952.

In addition to the full-scale tests, four or more safety experiments are being conducted. The first of these was held April 24 and the second, July 1. These experiments are not tests of stock-piled weapons, but are experiments intended to determine which among several designs afford the maximum assurance of safety and handling and storage of operational weapons. It is possible that the experiments may involve some nuclear reaction, as a part of the effort to learn how to avoid them should an accident occur. Several of these experiments will be detonated in underground shafts.

1957 Shots

The first shot of the 1957 series (Boltzmann) was fired at 4:55 a.m. May 28, after being ready since May 16. Unacceptable weather resulted in 12 one-day postponements. Boltzmann had a planned yield in the range of one-half nominal.

Franklin, the second shot - well below nominal in yield - was fired from a 300-foot tower at 4:55 a.m. on June 2. Franklin was ready on May 29, and was postponed four times because of unfavorable winds.

The first detonation of a balloon shot (Lassen) occured on June 5, after a one-day postponement for technical reasons. Lassen was a well below nominal shot from a 500-foot high balloon.

The fourth shot (Wilson) was fired at 4:45 a.m. June 18, from a 500-foot high balloon after three days of postponement for technical reasons. The predicted range of yield was from well below nominal to about half nominal.

The fifth shot (Priscilla) was fired at 6:30 a.m. June 24, from a 700-foot balloon after one 24-hour postponement. The predicted range of yield was above nominal.

A non-detonation resulted when an attempt was made to fire the sixth shot (Diablo) on June 28. The device was not detonated because the power source to the tower cab was accidentally disconnected at the tower base during removal of the elevator and elevator transformer. It was the third time a device had failed to detonate in Nevada. The first was on October 19, 1951, when a mechanical fault in a key electrical test circuit between the Control Point and the tower caused a non-detonation. The device was fired three days later. The second was on May 20, 1952, when a shot was prevented from detonating by a built-in checking device because a key experiment was not receiving data. It was fired five days later.

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The sixth shot (Hood) was fired July 5 after a number of technical delays. Placement was in a balloon-suspended cab 1500 feet above ground level. It was confirmed that the yield was well above the highest yield shot previously fired in the Continental United States.

Shot Names

Los Alamos Scientific Laboratory in the 1957 series is using the names of deceased scientists as code names for its shots.

The Livermore Laboratory is using the names of mountain peaks for all of its full-scale shots in the series.

Two shots of primary importance to the Department of Defense were not named for scientists or mountain peaks. One of these is the "Priscilla" shot.

Dual and Triple Capability

During the 1955 series, a "dual capability" scheduling was employed for the first time, when several times during the series two shots, one of greater sensitivity and one of lesser, were scheduled for firing on the same day. Often under weather conditions that were unacceptable for firing the more sensitive shot, the lesser one could be fired. This resulted in expediting the series.

The same concept has been adopted for the 1957 series, and resulted early in the series in the first (Boltzmann) and second (Franklin) shots being ready for firing on the same day.

In situations involving repeated postponements, it may be that tripl capability will result, where any one of three shots might be fired depen ing on weather. In such a situation, the most sensitive shot would be fi if the projected fallout pattern were acceptable; if it could not be fired, the next shot in sensitivity would be considered for firing, and finally the least sensitive shot would be considered if neither of the other two could be fired.

Yield Range of a Device

Yield of an experimental device usually is not projected by the design laboratory as a specific figure, but is estimated to the Test Organization as a range from a predicted low to a predicted high figure. In some instances the variation may be rather small, as from eight to ten kilotons; in others it may be much larger, as from three to ten kilotons.

While the yield actually achieved is of course important to the design laboratory, the technical success of the experiment does not depend on whether the yield is within the high or the low range of the estimate.

In evaluating public safety factors while determining whether a shot is to be fired, the Test Organization always considers the yield as if it will be at the highest predicted kiloton level.

The "Open" Shots

U.S. and foreign news media and a limited number of representatives of civil defense organizations are being admitted on-site to observe nine of the shots during the 1957 series.

The tentative schedule of remaining shots for on-site observation by civil defense and news media representatives follows. The schedule denotes whether the yield of each is planned to be greater or smaller than "nominal" - 20 KT:

DATE	APPROXIMATE YIELD	PLACEMENT
1. July 14	Below nominal	Tower
2. July 19	Below nominal	Air-to-air
3. July 20	Below nominal	Tower
4. July 24	Below nominal	Tower
5. August 15	Below nominal	Tower
6. August 19	Above nominal	Tower
7. August 23	Above nominal.	Balloon
8. September 1	Below nominal	Tower

The Hood shot on July 5 included extensive troop maneuvers by some 2,500 Marines.

The August 19 shot will include an army exercise involving 2,100 troops.

Each representative of recognized U. S. News Media applying for admission must:

a. Attach to his request for admission a statement signed by a principal official of the news organization employing him certifying that he is credited as the representative of his organization to report the test, and that he is a United States citizen;

b. Prior to admission to the Nevada Test Site, sign an agreement to abide by the safety and security regulations of the Nevada Test Organization;

c. Submit any camera equipment for inspection for compliance with limitations imposed on lens size and shutter speed. (Photography may be limited to the detonations and subjects at the observation point.)

Observers are expected to provide their own transportation to Mercury gate entrance to the Nevada Test Site, 65 miles from Las Vegas. Transportation is furnished by the Nevada Test Organization to the test area from the Mercury gate.

The only communications available at the observation point for immediate reporting from the test site are five telephone lines.

Interviews with Federal Civil Defense Administration observers, and with Nevada Test Organization participating personnel, will be arranged on request if and when practicable. Personnel conducting the tests are extremely busy, and it is only rarely that they can be available except at formal occasions such as pre-series briefings.

About 60 persons from civil defense organizations are being invited by the Federal Civil Defense Administration to witness each of the nine tests to which uncleared observers are admitted.

In addition military and/or civil defense observers from 47 foreign nations are being invited to witness test shots. The Federal Civil Defense Administration has invited civil defense representatives from the North Atlantic Treaty Organization to witness specified shots. The Department of Defense has invited military observers from member nations of NATO, the Southeast Asia Treaty Organization, the Inter-American Defense Board, the Permanent Joint Board of Defense (Canada-U.S.), and the Baghdad Pact.

All of the 47 nations invited to send either military or civil-defense observers have also been informed that news media representatives from these countries may be present to report at least one of the series open to reporting by United States media.

The purpose of inviting the attendance of observers and news media reporters from these 47 nations is to familiarize them with United States nuclear weapons testing policies and operations, especially safety procedures.

10. BALLOONS, TUNNELS AND ROCKETS

Three previously unused placements of nuclear devices are being employed in the 1957 series. Several balloon shots have been announced. One shot will be detonated in a deep underground tunnel, and there will be an air-to-air rocket detonation of a nuclear device.

A primary purpose for suspending devices on balloons is the reduction of nearby radioactive fallout. It is hoped that a device fired deep underground will eliminate essentially all airborne fallout.

The ideal positioning from the single viewpoint of the scientist would be, for most shots, on the surface. This would greatly simplify installation of data recording equipment and avoid climbs up 500-foot towers.

Because such shots must be very seriously limited as to yield permitted because of resultant fallout, almost all Nevada devices are placed high above the ground. In the past they have been detonated on towers up to 500 feet, or dropped from aircraft to explode well above ground level. No air drops are scheduled during the current series.

/c In this series there will be one tower of 700 feet - a long stretch for some instrumentation.

Thus, there will be at least four types of positioning, with each type presenting different requirements for instrumentation.

Air-to-Air Rocket

The air-to-air rocket shot will be an effects experiment designed to test certain important facts of a known warhead at a stated distance. It will not be a proof test or demonstration.

The safety of such an experiment was considered at great length before the test was scheduled in Nevada. Possible effects were considered such as the maximum range of missiles, the possibility of non-detonation at the prescribed point and the possible consequences of non-firing, and the need to obtain important experimental data on the performance of the missile system.

It was decided that the technical data required could be obtained and safety considerations could be satisfied by detonating the missile at a prescribed position in space rather than by using a drone aircraft or a towed object as a target.

Considering the maximum range of the missile, the known delivery altitude, and the prescribed zero point in space, it seems assured that the detonation will occur within bombing range.

The rocket will be fired from a manned Air Force aircraft. The missile test will come about mid-way in the 1957 series.

Tunnel Shot

Solely because it should completely prevent airborne radiation, one test shot of relatively low yield will be detonated in a deep underground tunnel. The tunnel will be practically horizontal, 1,900 feet into the side of a mountain.

The tunnel shot is not now planned as an observer shot. Actually there will be little to see since the detonation will be in a deep tunnel - deep enough so there will be no cloud.

It is believed that testing devices deep underground may have the dual advantage of eliminating fallout, and making it possible to shoot in any kind of weather.

The most difficult problem encountered has been the re-design of recording equipment which must go underground with the explosive device.

Balloon Shots

First flight experiments to determine the feasibility of using captive balloons as detonation platforms in nuclear tests were conducted in 1955 and 1956 in the Albuquerque, New Mexico area.

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Intensive experiments began in late January 1957 at the Nevada Test Site. All the tests were conducted by the Sandia Laboratory of Albuquerque. The tests determined the adequacy of safety controls, handling procedures and stability. The field tests assured that rigging had been devised which would hold the balloons and prevent their escape. They assured also that a deflation system, devised to lower the balloon quickly whenever necessary, such as during high winds, was satisfactory. The safety device burns a large hole in the top of the balloon so the helium inside the balloon can escape rapidly. This causes the balloon to come down immediately. Balloon tests have been made under many conditions, such as in high winds and thunderstorms, and because of such experiments, the Test Organization has expressed confidence that there will be no difficulty in controlling the balloons during actual detonations of nuclear devices conducted with balloons.

Two balloon sizes are being used during Plumbbob. One type is 67 feet in diameter and the other 75 feet in diameter. The smaller balloon will lift a one-ton device to 1,500 feet and still have enough lift to provide control. The larger balloon will lift about two or two-and-a-half tons to the same altitude and still provide sufficient lift for control.

The shot balloons are anchored with four cables, including a main vertical cable and three guy cables, all operated by remotely controlled winches located in heavily shielded underground bunkers. Operation of the cables is from the Control Point where an operator sits at a console with buttons for pulling in or letting out the cables. The operator has before him two television screens which picture the balloon's precise location through the use of two television cameras located on the ground near the balloon. The control cables have dynamometers to relay to the operator the amount of tension on each cable. Maneuvering the cables helps prevent the balloon from moving.

If any one of the cables should break because of high winds or other strain, the operator first would attempt to operate and lower the balloon by manual control. Should this system fail, the operator can activate an automatic deflation device at the console in the Control Point. Should neither of these systems work for any reason, a barometric device would activate the deflation system at a certain altitude should the balloon escape. Should the barometric system fail, the balloon automatically will split its seams and descend when it reaches 5,000 feet over ground level. Because a balloon moves somewhat even in slight winds, recording devices such as cameras and collimators have been re-designed to obtain adequate scientific data during balloon-borne nuclear tests. Some instrument recordings will be carried by cable to underground bunkers.

Balloons are used for tests not requiring the precise positioning for which towers are necessary. Detonation from a balloon, because it can be flown higher than the top of any tower used so far, will significantly reduce the amount of surface materials drawn into the radioactive cloud and later deposited as nearby fallout. The balloon as a detonation platform is very much less expensive than a tower. The principal purpose in using balloon suspension is to decrease nearby fallout, to permit better scheduling by avoiding long weather delays, and to obtain better positioning at higher altitudes than would be possible through air drops which might otherwise be necessary on some shots in the Plumbbob series, but which now are scheduled on balloons.

Another consideration in the use of balloons is the fact that there is a practical limit to the height of towers for supporting nuclear shot devices. This limit has two factors:

(1) The limitation of weight in that it is not practical to build a 1,500-foot tower, for example, that would support two tons or so; and,

(2) A point is reached when it would not be appropriate to use towers because the increased amount of tower material would add materially to the nearby fallout. At a certain altitude, ground material no longer is picked up into the fireball and this is advantageous. However, at some higher point, the increased material vaporized into the fireball from the tower itself offsets the lack of ground material. Balloons solve this problem by providing very little fallout material. The helium in the balloon may be heated by the nuclear reaction during a detonation but there is no other physical effect.

11. SAFETY AND RADIATION PROTECTION

As in past series, safeguarding the public health and safety is a primary consideration in the Plumbbob series of nuclear tests.

Because of improved controls and procedures, radioactive fallout in the area around the Test Site is expected to be even lower than the levels which have resulted from previous tests in Nevada. For the United States as a whole, average exposure will be small in comparison with the radiation dosage normally received from natural "background" radiation. Fallout levels in other parts of the world as a result of the tests generally will be lower than those in the United States.

Systems of detecting and measuring fallout radioactivity have been expanded and improved in order to provide more extensive data for scientific purposes and for informing the public. Radiological monitoring will be conducted by several networks of stations extending from the Test Site region to locations around the world.

Each test scheduled for Operation Plumbbob has been carefully evaluated to determine that it is necessary for achievement of the overall objective of strengthening the military and civil defense of the United States and the Free World.

An advisory panel of the Test Organization has the responsibility of weighing carefully all factors related to the safety of the public. A series of meetings is held before the firing of each shot, with the principal function to evaluate off-site fallout.

To assist in these deliberations, a complete weather unit is in operation at the Nevada Test Site, drawing upon all the data available from the U. S. Weather Bureau and the Air Weather Service, plus six additional weather stations ringing the test site. These data are evaluated for the current and predicted trends up to one hour before shot time. A shot can be cancelled at any time up to a few seconds before the scheduled detonation.

Reduction of Fallout

Controls and procedures for the test series were designed to assure that exposure of the public in the Test Site region for the entire series will be below the Commission's basic guide of 3.9 roentgens of whole-body exposure to gamma rays. In its day-to-day operations, the Test Organization tries to hold public exposure to fallout as near zero as possible.

Procedures for keeping fallout at a minimum include the following:

(1) The Test Organization has established criteria defining the maximum permissible yield for devices exploded at specified altitudes. If the fireball produced by any detonation is expected to reach the surface of the Test Site, drawing up dust and debris into the atomic cloud and thereby increasing local fallout, there are severe restrictions on the weather conditions considered acceptable for the test. Such tests are conducted only when predicted weather conditions will not produce significant fallout on any inhabited locality. Improved weather forecasting techniques and high-speed electronic methods of predicting fallout paths and intensity are utilized.

(2) There has been a continuing effort in the weapons laboratories to design devices of the lowest possible yield which will provide the desired scientific data. Decreasing the yield of a device has the effect of decreasing the amount of radioactive fission products which can descend as fallout.

(3) Improved techniques such as balloons are being utilized to keep the fireballs of the detonations away from the surface of the testing area. Relatively little local fallout results from detonations in which the fireball does not approach close to the surface.

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Warning Procedures

As in the past series, every effort is being made to warn people away from the Test Site and the Las Vegas Bombing and Gunnery Range. A Civil Aeronautics officer again is assigned to the Test Organization to provide for closure of air space if necessary to prevent exposure of persons in aircraft.

Persons in the Test Site area also are advised of precautions to take against the brilliant flash of light and the shock wave from the detonation. No member of the public has suffered eye damage in past series from the light flash. Minor damage from the shock wave occurred in some nearby communities, principally in the earlier series.

Radiation Exposure Levels

Many thousands of measurements of fallout radioactivity have been made in the Test Site area since the beginning of testing in Nevada in 1951. These measurements have confirmed that Nevada test fallout has not caused illness or detectable injury to health.

The highest fallout level noted to date in an inhabited place outside of the Test Site occurred in 1953 at a motor court near Bunkerville, Nevada, where about 15 people might have accumulated 7 to 8 roentgens if they had continued to live there indefinitely. The highest estimated total exposure to a community has been 4.3 roentgens at Bunkerville.

Most of the communities in the Test Site area have received less than one roentgen total estimated exposure as a result of the six years of testing in Nevada.

The National Academy of Sciences - National Research Council in a 1956 report recommended "....that individual persons not receive more than a total accumulated dose to the reproductive cells of 50 roentgens up to age 30 years (by which age, on the average, over half of the children will have been born), and not more than 50 roentgens additional up to the age 40 (by which time about 9/10 of their children will have been born....) ...."and....that for the present it be accepted as a uniform national standard that X-ray installations (medical and non-medical), power installations, disposal of radioactive wastes, experimental installations, testing of weapons, and all other humanly controllable sources of radiations, be so restricted that members of our general population shall not receive from such sources an average of more than 10 roentgens, in addition to background, of ionizing radiation as a total accumulated dose to the reproductive cells from conception to age 30...."

Natural background radiation is roughly 4 roentgens per 30 years. Thus the value for man-made sources (stated by the National Committee on Radiation Protection and Measurements) becomes about 10 million roentgens per million population. This particular recommendation applying to radiation per million of population was selected because of genetic considerations, that is radiation doses to relatively large populations. The average exposure to those communities around the Nevada Test Site that experienced the greatest amount of fallout (.2 roentgens or more) is .6 roentgens for the six years since the nuclear tests started. The actual round numbers for their exposure are 58 thousand roentgens per 100 thousand people. This is, of course, of less genetic significance than a .6 roentgen average exposure to one million people. Even if it had the same significance, .6 roentgens for six years is at the rate of 3 roentgens per 30 years, or only about 1/3 of the value called for by the National Committee on Radiation Protection and Measurement. In an area around the Nevada Test Site which includes the nearest one million people, the average exposure has been only about one-tenth of a roentgen for the six years, or at a rate of about 1/2 roentgen per 30 years. This is 1/20 of the NCRP value.

Outside the Test Site region, the total dose since the beginning of nuclear testing generally has been a very small fraction of a roentgen - considerably less than the average exposure to natural "background" radioactivity which persons have received over the same time period. Roughly speaking, the additional exposure resulting from test fallout outside the Test Site region has been about equivalent to the additional exposure to background radiation which a person would receive by moving from sea level to a locality a few hundred feet higher in altitude. (Background radiation levels increase with altitude because of an increase in cosmic ray frequency.)

Fallout radioactivity noted in other countries has been even less. Except for some of the Pacific islands, the cumulative gamma dose at foreign monitoring stations from October 1951 to September 1955 ranged from four to 23 thousandths of one roentgen.

Many measurements of the strontium-90 content of soil, food and feed crops, milk, meat and human bones have been made, since strontium-90 is considered to be potentially the most hazardous fallout material when taken into the body. None of these measurements has disclosed a dangerous concentration of strontium-90 from Nevada test outside of the controlled areas of the Test Site.

Radiological Monitoring

The Test Organization's monitoring program is concentrated largely in the region up to 200 miles from the Test Site. Outside of this area, other monitoring networks provide information on levels of radioactivity in the United States and in other parts of the world. The U. S. Public Health Service, the U. S. Weather Bureau, and 11 Commission installations cooperate in this monitoring activity.

Monitoring programs have been expanded in several respects to provide more detailed information on the distribution of fallout and the exposures resulting from it. The monitoring stations detect whatever radioactivity is present in their localities, whether it

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results from the Plumbbob tests or from foreign nuclear tests. Therefore, when foreign tests are held during the series, the readings may represent fallout from these as well as from the U. S. tests.

Cloud Sampling and Tracking; Airborne Monitoring

Manned Air Force aircraft are used to take samples of atomic clouds at various altitudes. These planes are flown through the radioactive cloud and collect "hot" samples which are flown to AEC laboratories for analysis. Air Force planes also track the atomic clouds from the Test Site for up to 600 miles, by which time they have dispersed into invisible, diffused air masses.

Aircraft also are used after each shot to determine the fallout pattern on the ground and to provide estimates of radiation intensity. Three airplanes, equipped with instruments of the type developed by Oak Ridge National Laboratory to locate uranium ore deposits from the air, take part in the airborne monitoring operation.

Paths of Radioactive Clouds

Many considerations affect a "go" decision on shots in Nevada, and a majority of these are related to the radioactive fallout which may result on any community near the Test Site.

Distance of a community from ground zero is one of the prime considerations. Following are approximated air miles between the center of Yucca Flat and the nearest communities off-site. This list shows first the Government installations and the communities to the southeast and west of the Test Site, then moves clockwise around the Test Site.

Camp Mercury, 25 miles; Indian Springs AF Base, 37 miles; Las Vegas, 90 miles; Lathrop Wells, 37 miles; Beatty, 42 miles; Goldfield, 80 miles; Tonopah, 95 miles; Warm Springs, 80 miles; Reed, (2 people) 46 miles; Nyala, 80 miles; Adaven, 75 miles; Lincoln Mine, 42 miles; Groom Mine, 24 miles; Ely, 162 miles; Pioche, 105 miles; Caliente, 90 miles; Hiko, 60 miles; Alamo, 52 miles; Glendale Junction, 90 miles; Bunkerville, 110 miles; St. George, 135 miles; Overton, 100 miles.

Direction of the atomic clouds after past shots has drawn considerable attention after newsmen reported that some people living in or near Tonopah have felt that a majority of the shots fired at Nevada Test Site have resulted in the clouds blowing toward Tonopah and that almost no clouds have blown toward Las Vegas. The following summary lists the 45 shots fired between January 27, 1951, and May 15, 1955, and the direction in which the major cloud was blown after the shot by the winds:

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Ranger, Winter 1951:

Jan. 27, due east; Jan. 28, southeast over Las Vegas and Nellis AF Base; Feb. 1, southeast over Las Vegas; Feb. 2, southeast over open area north of Nellis AFB, but with part of cloud over Las Vegas and Nellis; Feb. 6, slightly west of due south, over Charleston Peak to Los Angeles.

Buster-Jangle, Autumn 1951:

Oct. 22, south-southwest; Oct. 28, southeast, slightly north of Las Vegas; Oct. 30, southwest into Death Valley; Nov. 1, southeast, Las Vegas and Henderson; Nov. 5, south to southeast, over Mt. Charleston and Las Vegas; Nov. 19, north-northeast, Lincoln Mine, Currant, Eureka, Currie; Nov. 29, north-northeast, almost same route.

Tumbler-Snapper, Spring 1952:

April 1, east; April 15, main cloud southeast; low cloud south; April 22, southeast, Las Vegas; May 1, due east; May 7, slightly north of due east; May 25, north of due east; June 1, due north in area between Warm Springs and Currant; June 5, east or due north (on this shot the pre-shot projection was for center line of fallout to be some miles east of Tonopah).

Upshot-Knothole, Spring 1953:

March 17, east; March 24, northeast; March 31, southeast Indian Springs and Las Vegas; April 6, southeast, Las Vegas; April 11, south; April 18, Southeast, including Glendale and Las Vegas; April 25, east to St. George; May 8, south of east; May 19, due east; May 25, northeast; June 4, southeast, Nellis AFB and Las Vegas.

Teapot, Spring 1955:

Feb. 18, southeast, open land between Glendale and Las Vegas; Feb. 22, southeast, same as above; March 1, north of due east; March 7, east for main, higher cloud; and west, northwest for lower cloud, (very, very light fallout on Tonopah); March 12, east; March 22, southeast, Las Vegas; March 23, southeast, Las Vegas; March 29, north of east; April 6, south-southeast; April 9, south, southeast; April 9, south and west of south; April 15, east and slightly northeast; May 5, north; May 15, northeast by east.

The above detailed list may be summarized to show the following general directions:

Southeast, 17 shots, 12 of which resulted in the main cloud or major edges of clouds passing above Indian Springs AF Base, Las Vegas, Henderson, and Boulder.

East, $13\frac{1}{2}$ shots. (The cloud from the March 7, 1955 shot moved in two directions and each is given a value of one-half.)

Northeast, 5 shots.

North, 3 shots.

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Northwest, no shots. (It is noted here, however, that the March 7, 1955, cloud went west and later curved around to Northwest short of Tonopah.)

West, 1/2 shot.
Southwest, 2 shots.
South, 4 shots.

Tonopah is almost due northwest of Nevada Test Site. Analysis of the record shows that only the outer fringes of one cloud went near Tonopah in six years of testing, while the main cloud or substantial portions of it went over Indian Springs, Las Vegas, Nellis AF Base, and Henderson on 12 occasions.

It is obvious from the above that the Nevada Test Organization does not "wait until the cloud will go north or northwest before firing."

<u>Factors considered:</u> There are some shots in which the detonation will be sufficiently above the earth's surface so the direction and speed of winds is not too important. Possibly the determining factor in such instances would be the possibility of rain or snow from an altitude above that of the atomic air mass at some point within 200 or 300 miles downwind. The key factor on such shots is that they do not result in early deposition of fallout.

Surface or shallow underground shots would create heavy, very early fallout. For this reason, there are serious restrictions on the yield which would be permitted under such positioning, and stringent criteria as to wind directions and strength are established. Such shots would not be fired unless the wind was out of almost due west, west-northwest, southeast, or south, so that all early fallout would be on the Test Site and on nearby, unoccupied portions of the Las Vegas Bombing and Gunnery Range.

A number of shots at NTS offer the potential of fairly heavy early fallout. These are almost exclusively tower shots in which the fireball will touch the ground (none of which are scheduled for the Summer 1957 series) or those which will create fallout out of the tower or materials and instrumentation associated with the tower cab. For these shots, much more stringent criteria apply than for high air bursts (such as with balloons or air drops), although they are less stringent than apply to surface or shallow underground shots.

It has frequently been reported that on shots such as those discussed immediately above the only hazardous fallout has been, and would be, within no more than perhaps up to 20 miles from zero point, which in every case would be within the Test Site or adjacent areas of the Bombing Range. The levels of radiation in the hottest hot spot within the 20 miles has in one instance equalled an infinity exposure rate of 30 roentgens, or an estimated lifetime dose of 18 roentgens. There may, however, be less but still undesirable fallout at greater distances. This might range from 4 roentgens to perhaps 10 roentgens. It is very seldom that forecasts indicate fallout levels anywhere in inhabited places near the Test Site that would exceed 3 to 6 roentgens, but when such levels are indicated the shot is, of course postponed.

It is the possibility of heavy fallout within 20 miles and undesirable fallout within perhaps 30 or 40 miles which prevents firing when the winds are out of the north or the west-of-north, and sometimes when they are from other directions.

The prevailing winds in southern Nevada are westerlies and south-westerlies. For this reason, the permanent on-site control structures were located to the south of Yucca Flat (the area most used for detonations) and Camp Mercury was located on the southern edge of Nevada Test Site. Camp Desert Rock is in the same general area as Mercury. The location of the Control Point, which contains much film and other sensitive material, of troop and other observer areas, of Camp Mercury, and of Camp Desert Rock (all being within range of heavy, early fallout on the more sensitive shots) prevents firing when winds are out of the north. Shots have, of course, been fired many times when the atomic cloud was blown overhead to the south -- but these were shots which did not involve heavy early fallout.

Indian Springs AF Base is only 37 miles to the southeast. Its location has caused postponements on many shots where stronger winds, without shear, would result in unacceptable fallout across the air base. It is usually the presence of Camp Mercury or of Indian Springs AF Base which has caused postponements of "sensitive" shots on occasion, not the presence of Las Vegas which is about 90 miles southeast of the center of Yucca Flat.

For like reasons, close attention is also always paid to Groom Mine, which is about 22 miles northeast from the center of Yucca, and to Lathrop Wells, about 37 miles to the southwest.

Outside of the four areas mentioned, to the southwest, south, southeast, and northeast, the direction which will be acceptable on such shots depends largely on wind speeds and wind shear, inasmuch as in all other directions there are quite a few miles of Test Site or unoccupied Bombing Range before occupied places are reached.

Three directions from Yucca are most desirable. If wind speeds are low and if the winds at various altitudes are from different directions, the result will be a short, widely-diffused fallout pattern. In such instances, the areas immediately east, north, northwest are fully acceptable, because of the open spaces and the distances to occupied places. Most of such shots have been fired while winds were blowing into the east solely because winds in Nevada usually blow in that direction. If winds blew out of the southeast, more shots would be fired with winds blowing into the northwest.

Maps used by the Test Organization place a 10-mile buffer zone around all occupied places in the region out to 100 to 150 miles. Shots are fired only if it appears that fallout will be very light on such places. If it appears that fallout may occur which is in multiple roentgens or approaches the conservative off-site guide of 3.9 roentgens in one year, the shot would of course be postponed. Computations allow sizable margins for the errors which necessarily accompany pin-pointed forecasts of wind directions.

Monitoring Teams in Test Site Area

The off-site monitoring program for Operation Plumbbob was organized to take numerous radiological measurements and to provide close liaison with the citizens of nearby communities. U. S. Public Health Service personnel assigned to the Test Organization operate the programs under which the area around the Test Site was divided into 17 zones. One or more technically qualified men have been assigned to live in each zone. Their duties consist not only of normal monitoring activities but also, prior to and during the test series, of learning the communities and families in their zones, getting to know the people and being known by them. Teams are stationed at Las Vegas, Alamo, Caliente, Pioche, Ely, Tonopah, Mercury, Lincoln Mine, Overton, Mesquite, and Eureka (Nevada); St. George, Cedar City and Beaver (Utah); Barstow and Bishop (California); and Kingman (Arizona).

In addition to the zone monitors there are eight mobile monitering teams on call to go to any locality to assist if needed or to travel to areas outside the 17 zones.

(Twelve fixed-station teams and four mobile teams were utilized during the 1955 Nevada series.)

The monitors distribute and collect film badges (used for measurement of radiation dosage), monitor radioactivity on the ground and in the air, collect water and milk samples, and answer public inquiries regarding test fallout.

Film Badges

Since photographic film is extremely sensitive to radiation, badges containing film have been used extensively in the atomic energy program to measure radiation exposure.

During the 1955 series, badges were placed on the interiors and exteriors of buildings in the Test Site area, on trees, fence posts and fences in communities and in the open country. In addition, some of the residents of the nearby area wore badges as a means of aiding the Test Organization in determining the radiation exposure actually experienced by persons in the area. A total of 555 such film badge "stations" were used in the 1955 series.

More than 2,000 film badge stations have been established for the 1957 series. In several small communities near the Test Site, all residents except infants and small children have been asked to wear the badges throughout the series. (Infants and small children are likely to chew or otherwise damage the badges, making it impossible to obtain accurate measurements, or to damage themselves swallowing the badges.)

A more detailed program has been established at Alamo, a town of about 400 persons located 55 miles northwest of the Yucca Flat firing area. Alamo was chosen as a representative town of the Test Site region.

In addition to wearing film badges, Alamo residents are asked to report their movements inside the region and to other localities, and also to provide information on other activities which might affect radiation dosage, such as the amount of time spent indoors as compared with outdoors. Each person also is being asked for details of previous exposure to radiation, such as medical X-rays.

This project has two major purposes:

(1) To obtain information on how fallout radiation exposures are affected by movement, shielding provided by buildings, weathering of the fallout material by wind and rain, and other factors.

(2) To obtain information on the problems which might be encountered in attempting to record the radiation exposure of a relatively large group of persons through the use of film badges.

Physicians and Veterinarians

Two physicians of the U. S. Public Health Service have been assigned to the Test Organization at Camp Mercury for the duration of the 1957 series. They are Dr. Samuel C. Ingraham and Dr. Eugene Van der Smissen, both of Washington, D. C. Dr. Ingraham serves as coordinator within the Test Organization for the USPHS National Monitoring Network. Their duties include maintaining liaison with private physicians in the NTS region and assisting them in diagnosing any ailment which the patient feels may have resulted from any test effect, including exposure to radiation.

Two veterinarians are serving the Test Organization in maintaining liaison with regional veterinarians, public officials and stockmen, and in investigating alleged test-effected injuries to animals. They are Lt. Edward L. Johnson, who is permanently assigned to the Atomic Energy Commission's Las Vegas Office, and Dr. Arthur H. Wolff, Senior Veterinarian with the Occupational Health Division of the Public Health Service at Cincinnati, Ohio who has been assigned to serve during the series.

Automatic Radiation Reporting System

At least 30 continuous radiation recorders have been placed in nearby communities to record the time of arrival of any fallout, intensity, and in some cases, the effect of shielding by structures.

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Such equipment was placed in operation to monitor fallout radiation during the 1953 test series, and refined equipment of the same type was used again in 1955. The system involves the transmission of radiation information by means of long distance telephone lines for off-site detector locations, by means of direct field wire for stations within about 15 miles of control stations and which are not accessible by commercial telephone lines; and by means of radio link where neither telephones nor field line transmission is feasible.

The equipment permits a single operator to obtain radiation data from the 30 stations which are located from 50 to 350 miles from the Nevada Test Site. The operator at the site simply places a telephone call to the station in the usual manner when information is sought. The station answers automatically, sends in its data, then hangs up. Field stations and radio stations are reached similarly by the operator from the control console. Stations were placed on the basis of fallout patterns from previous tests and on the basis of population density. They are located generally so as to supplement the manned teams of off-site radiation monitors. After each shot, information from radiation recorded in each station is obtained even from areas where no fallout has been predicted.

The fallout data is made available to the off-site radiation safety unit for use in evaluating the significance of fallout and as a cross check with other data collection units and programs.

Location of the stations and the distances in miles from the Nevada Test Site follow:

Alamo 50, Austin 180, Carson City 245, Elko 260, Ely 170, Eureka 170, Hawthorne 175, Henderson 80, Logandale 80, Pioche 110, Reno 260, Tonopah 100, Wells 280, Winnemucca 280, (Nevada); Barstow 156, Lone Pine 115, Needles 150, (California); Beaver 195, Cedar City 165, Delta 245, Eureka 280, Kanab 205, Manti 275, Mount Pleasant 290, Parowan 175, Provo 315, Richfield 240, St. George 135, Salt Lake City 330, (Utah); Kingman (Arizona), 160

Other Data Collecting Projects

Several hundred fallout trays, coated with waterproof adhesive, have been distributed in areas generally adjacent to the Test Site. The contents are collected regularly and analyzed for beta particle fallout.

The Atomic Energy Project of the University of California, Los Angeles, is utilizing the test series to continue studies of the uptake of fission products in plant and animal life and the distribution of fallout particles. The Project has conducted such studies in connection with all continental tests since the first one in 1945.

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UCLA scientific personnel obtain soil and plant samples and hunt and trap wildlife and rodents in fallout areas from the Test Site out to about 160 miles. They also study the distribution of fallout particles of different sizes with the objective of providing information which can be used in the prediction of fallout patterns.

If fallout is recorded in areas within California, Utah or Nevada where crops are grown, samples of soil, forage crops, vegetables and milk will be collected to learn more about the biological availability of fission products.

Monitoring in Continental United States

Outside of the area within about 200 miles of the Test Site, monitoring activities are conducted in cooperation with the U. S. Weather Bureau, the U. S. Public Health Service, and 11 Atomic Energy Commission installations. These operations are not conducted in the expectation of possible hazard, but for scientific purposes and to keep the public informed on levels of radioactivity.

As in past test series, a network of U. S. Weather Bureau stations collects dust samples. The stations expose sheets of film covered with adhesive outdoors on a tray each for 24 hours, and then mail them to the Commission's Health and Safety Laboratory in New York. There, the samples are reduced to ashes and the radioactivity measured with extremely sensitive instruments.

Ninety-three Weather Bureau sampling stations are in operation during Operation Plumbbob. Their locations are:

Abilene, Texas; Albany, New York; Albuquerque, New Mexico; Alpena, Michigan; Amarillo, Texas; Atlanta, Georgia; Bakersfield, California; Baltimore, Maryland; Billings, Montana; Binghamton, New York; Bishop, California; Boise, Idaho; Boston, Massachusetts; Buffalo, New York; Caribou, Maine; Casper, Wyoming; Charleston, South Carolina; Cheyenne, Wyoming; Chicago, Illinois; Cleveland, Ohio; Colorado Springs, Colorado; Concord, New Hampshire; Corpus Christi, Texas; Concordia, Kansas; Dallas, Texas; Del Rio, Texas; Denver, Colorado; Des Moines, Iowa; Detroit, Michigan; Elko, Nevada; Ely, Nevada; Eureka, California; Fargo, North Dakota; Flagstaff, Arizona; Fort Smith, Arkansas; Fresno, California; Goodland, Kansas; Grand Junction, Colorado; Grand Rapids, Michigan; Green Bay, Wisconsin; Hatteras, North Carolina; Helena, Montana; Huron, South Dakota; Jackson, Mississippi; Jacksonville, Florida; Kalispell, Montana; Knoxville, Tennessee; Las Vegas, Nevada; Los Angeles, California; Louisville, Kentucky; Lynchburg, Virginia; Marquette, Michigan; Medford, Oregon; Memphis, Tennessee; Miami, Florida; Milford, Utah; Milwaukee, Wisconsin; Minneapolis, Minnesota; Mobile, Alabama; Montgomery, Alabama; New Haven, Connecticut; New Orleans, Louisiana; New York (La Guardia), New York; Philadelphia, Pennsylvania; Phoenix, Arizona; Pittsburgh, Pennsylvania; Pocatello, Idaho; Port Arthur, Texas; Portland, Oregon; Prescott, Arizona;

Providence, Rhode Island; Pueblo, Colorado; Rapid City, South Dakota; Reno, Nevada; Rochester, New York; Roswell, New Mexico; Sacramento, California; Salt Lake City, Utah; San Diego, California; San Francisco, California; Scottsbluff, Nebraska; Seattle, Washington; Spokane, Washington; St. Louis, Missouri; Syracuse, New York; Tonopah, Nevada; Tucson, Arizona; Washington, D. C. (Silver Hill, Md.); Wichita, Kansas; Williston, North Dakota; Winnemucca, Nevada; Yuma, Arizona.

Although this collection system provides important scientific data, it does not provide immediate information on fallout levels, since the samples must be mailed to the Health and Safety Laboratory and counted there. Information is provided more quickly by two other monitoring networks, one consisting of 38 stations established by the U. S. Public Health Service and the other consisting of monitors at 11 Commission installations. The USPHS monitoring station locations are:

Albany, New York; Anchorage, Alaska; Atlanta, Georgia; Austin, Texas; Baltimore, Maryland; Berkeley, California; Boise, Idaho; Cheyenne, Wyoming; Cincinnati, Ohio; Denver, Colorado; El Paso, Texas; Gastonia, North Carolina; Harrisburg, Pennsylvania; Hartford, Connecticut; Honolulu, T. H.; Indianapolis, Indiana; Iowa City, Iowa; Jacksonville, Florida; Jefferson City, Missouri; Juneau, Alaska; Klamath Falls, Oregon; Lansing, Michigan; Lawrence, Massachusetts; Little Rock, Arkansas; Los Angeles, California; Minneapolis, Minnesota; Mercury, Nevada; New Orleans, Louisiana; Oklahoma City, Oklahoma; Phoenix, Arizona; Pierre, South Dakota; Portland, Oregon; Richmond, Virginia; Salt Lake City, Utah; Santa Fe, New Mexico; Seattle, Washington; Springfield, Illinois; Trenton, New Jersey; Washington, D. C.

The AEC monitoring station locations are:

Berkeley, California - Radiation Laboratory, University of California; Cincinnati, Ohio - General Electric Company, Aircraft Nuclear Propulsion Department; Idaho Falls, Idaho - Idaho Operations Office; Lemont, Illinois - Argonne National Laboratory; Los Alamos, New Mexico - Los Alamos Scientific Laboratory; New York, New York - New York Operations Office; Richland, Washington - Hanford Operations Office; Oak Ridge, Tennessee - Oak Ridge National Laboratory; Rochester, New York - The Atomic Energy Project, University of Rochester; Salt Lake City, Utah - Radiobiology Laboratory, University of Utah; West Los Angeles, California - Atomic Energy Project, UCLA.

The Public Health Service established its country-wide monitoring system in 1956 in connection with the Redwing series of tests at the Commission's Eniwetok Proving Grounds. The system has been reactivated for the new Nevada series.

The Public Health Service monitoring stations make daily readings of radioactivity and forward the data to a central collection office in Washington. The stations also report data to the State Health Officers of the states in which the stations are located.

Under a contract between the Public Health Service and the Commission, the monitoring system will operate throughout the series and for some weeks thereafter.

The primary purposes of the system are to give state and local health departments more experience in studying fallout and normal background radiation levels, and to obtain daily records of radioactivity. The stations are manned by trained technicians from state health departments, local universities and scientific institutions.

Measurements of Radioactivity Outside the U. S.

Dust samples are collected at 73 stations outside of the continental United States and extending around the world. Their locations are:

Addis Ababa, Ethiopia; Anchorage, Alaska; Bangkok, Siam; Beirut, Lebanon; Belem, Brazil; Bermuda; Buenos Aires, Argentina; Canal Zone; Canton Island; Churchill, Manitoba, Canada; Clarke AFB, Philippines; Colombo, Ceylon; Dakar, French West Africa; Deep River, Ottawa, Ontario, Canada; Dhahran, Saudi Arabia; Durban Natal, South Africa; Edmonton, Alberta, Canada; Fairbanks, Alaska; French Frigate Shoals; Goose Bay, Labrador; Guam; Hilo, Hawaii; Hiroshima, Japan; Honolulu, Hawaii; Iwo Jima; Johnson Island; Juneau, Alaska; Keflavik, Iceland; Koror; Kwajalein; La Paz, Bolivia; Lagens, Azores; Lagos, Nigeria; Leopoldville, Belgian Congo; Lihue; Lima, Peru; Melbourne, Australia; Mexico City, Mexico; Midway Island; Milan, Italy; Misawa, Japan; Moncton, New Brunswick, Canada; Monrovia, Liberia; Montreal, Quebec, Canada; Moosoonee, Ontario, Canada; Nagasaki, Japan; Nairobi, Kenya, East Africa; Nome, Alaska; North Bay, Ontario, Canada; Noumea, New Caledonia; Oslo, Norway; Ponape; Prestwick, Scotland; Pretoria, South Africa; Quito, Ecuador; Regina, Saskatchewan, Canada; Rhein Main, Germany; San Jose, Costa Rica; San Juan, Puerto Rico; Sao Paulo, Brazil; Seven Islands, Quebec, Canada; Sidi Slimane, French Morocco; Singapore; Stephenville, Newfoundland; Sydney, Australia; Tai Pei, Formosa; Thule, Greenland; Tokyo Air Base, Japan; Truk; Wake Island; Wellington, New Zealand; Wheelus AFB, Tripoli; Winnipeg, Manitoba, Canada; Yap.

Soils also are sampled on a world-wide basis, and samples of other materials such as milk and cheese, field crops, and human and animal bones are taken for analysis of their strontium-90 content. This program is part of the Commission's Project Sunshine, a study of the world-wide distribution and uptake of strontium-90.

Fallout Computers

Two electronic computers designed to provide a very rapid forecast of nearby radioactive fallout are being used for the first time in continental atomic tests during Operation Plumbbob.

Both machines furnish extremely fast information to the Test Organization on just where and in what amounts there may be fallout

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from any particular detonation, taking into account weather conditions (particularly wind speeds and directions at all altitudes) forecast for shot time.

In past test operations the Test Manager's decision to shoot or postpone a test has been based on similar computations worked out by the Nevada Test Organization's Fallout Prediction Unit. But since human computation is necessarily somewhat slower than that performed by the electronic devices, the time lag has required utilization of weather forecasts made earlier before scheduled shot time. This sometimes resulted in missed opportunities to fire a test when last-minute improvements in the weather outlook did not permit fallout computation in time to confirm public safety before shot time.

One of the computers produces almost instantaneous solutions, giving the Test Manager and his Advisory Panel the benefit of revised fallout predictions right up to shot time. This makes it possible to take advantage of improving weather, and would also help assure cancellation of a shot if a weather change for the worse was indicated in the immediate pre-shot weather forecast.

Both computers are used in addition to continuing human computation by personnel of the Fallout Prediction Unit. The human computation, although slower, serves to check the accuracy of the electronic computations.

Each of the computers is about the size of a large console-type home television set, and readily portable. One unit, developed by the National Bureau of Standards, actually contains a display device closely resembling a TV screen. This picture screen, which is lined similar to graph paper, provides a visual, quickly-interpreted pattern of fallout areas and their intensity. A map transparency of the Test Site area can be superimposed on the screen in order to pin-point the precise location of predicted fallout.

The other computer, developed by AEC Sandia Laboratory, differs from the NBS model largely in the fact that it provides results in the form of a graph or chart.

The Sandia-developed computer can be operated by technicians with little knowledge of higher mathematics. The NBS machine requires no mathematical experience at all. Data fed into the computers includes speed and direction of winds at various heights, size and shape of the atomic cloud, and characteristics of the various radioactive elements in the atomic cloud.

12. MILITARY PARTICIPATION

Personnel and equipment of the Army, Navy, Air Force and Marine Corps are participating extensively in Operation Plumbbob.

Of primary importance to the Department of Defense and the Armed

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Services is a series of military effects experiments designed to increase knowledge of the effects of atomic detonations upon military equipment, material, and personnel.

The Department of Defense programs and projects were planned and coordinated by the Armed Forces Special Weapons Project commanded by Rear Admiral Edward Parker, USN. Responsibility for the field conduct of these experiments; for coordination of all military participation in the tests; and for providing logistical support to the AEC and the Armed Forces and their laboratories is assigned to Rear Admiral Frank O'Beirne, USN, Commander, Field Command, Armed Forces Special Weapons Project at Sandia Base, New Mexico. Within the joint AEC-DOD test organization at Nevada, Admiral O'Beirne is represented by Colonel H. E. Parsons, USAF, who is Deputy Test Manager for Military Matters.

Camp Desert Rock, some five miles from Test Site headquarters at Mercury, Nevada, is the focal point of Army activity. This semi-permanent installation of 183 temporary buildings was opened in September 1951 to support observers and troops participating in AEC's test series. At present the camp has a population of some 1,700 support troops. Its population will fluctuate during the series and in troop maneuver periods will hit a peak of well over 5,000.

Indian Springs Air Force Base, some 20 miles from Mercury, also plays an important role in the Armed Forces activities in connection with the Tests. The USAF and the Navy have approximately 1,500 personnel and 120 planes engaged in Operation Plumbbob.

Military Effects Experiments

Military weapons effects experiments in the 1957 series were designed to extend knowledge of the effects of the damage-producing mechanisms of nuclear detonations on military equipment, personnel, tactics and techniques.

Among the military effects experiments are some new during this series, and some that are refinements of previous tests. On some shots, techniques are being tested again for the protection of personnel from the hazards of eye injury or temporary blindness from the atomic flash. Air Force personnel are participating in this program.

To insure maximum savings of life in the event of nuclear warfare, participating agencies in this test series again are using animals in their studies.

Until now, most biological data has been gathered using small animals such as rats and mice. There are important differences in response to weapons effects between different animal species. Many of the differences are based upon size. For this reason, it is very important to study effects on larger animals, thus permitting a more precise estimate of effects on man. One of the significant tests on animals in this series involved pigs. This experiment was conducted by surgeons and medical specialists of the Armed Forces.

One of the experiments involving the use of pigs in Plumbbob is a test of fabrics and materials to determine their capacity to withstand the heat (or thermal) effects of atomic detonations. On one shot in the series, approximately 70 Chester White pigs are being used to test a wide variety of fabrics and materials which might eventually contribute to the design of military uniforms. The pigs, placed in enclosures, are anethetized, and receive considerably fewer calories of thermal than they are capable of withstanding and surviving. No fatalities were expected.

U. S. Navy non-rigid airships, or "blimps", are being used in some shots to collect effects data. The Navy also will conduct effects tests on helicopters on many shots during the series.

The Air Force is continuing to collect data on the effects of atomic detonations upon in-flight aircraft.

These and all of the other military effects tests are conducted as a cooperative effort of the Armed Forces Special Weapons Project and the individual Military Services.

U. S. Army

The Army is participating in many test projects--test of ordnance material, test of field fortifications, evaluation of detonation and cloud tracking systems, field evaluation of shielding for engineer heavy equipment, evaluation of water decontaminating methods, troop test of atomic burst equipment, and four observer projects.

The Army will conduct an Infantry troop test in connection with the "open shot" scheduled for August 19, in which some 2,100 troops will employ new tactics which may be used on the atomic battlefield.

The test, which will see the use of two new types of Army units, the Infantry Battle Group and the Army Aviation Battalion, employed to repel a mythical attack by an aggressor force against Las Vegas, consists of three parts to be conducted over a four-day period.

Part I is an operation involving Infantry defense against an atomic explosion to determine and establish the troop support, material and equipment required by a battle group to construct a defensive position adequate for protection from the effects of an atomic explosion. Part II involves an aerial movement by helicopter of a battle group to an "enemy" objective 30 miles behind his front lines to determine tactical doctrine, organization, planning data and helicopter requirements for the movement of a battle group, by helicopter, to seize a deep objective in conjunction with the use of an atomic weapon. Part III involves the aerial re-supply entirely by helicopter of the battle group in the forward position for a two-day period to determine techniques and procedures necessary to effect re-supply, by helicopter, of a battle group.

Director of Exercise Desert Rock VII and VIII is Lt. General Robert N. Young, Commanding General of the Sixth U. S. Army, Presidio of San Francisco. Deputy Director is Brigadier General Walter A. Jensen, Commanding General of Camp Irwin, California.

U. S. Navy

The Navy is conducting a training project sponsored by the U. S. Navy Bureau of Yards and Docks. Navy personnel perform monitoring exercises in an induced field of comparatively low radiation.

The Navy is also conducting effects tests on non-rigid airships (blimps) and helicopters in many shots during the series.

Marine Corps

Approximately 2,500 Marines participated in a combined air-ground exercise in connection with the Hood shot detonated July 5. This maneuver was a further test of the Corps' established doctrine of "vertical envelopment" in tactical atomic warfare.

The Fourth Marine Corps Provisional Atomic Exercise Brigade, commanded by Brigadier General Harvey C. Tschirgi, conducted the exercise. Making up the Brigade are elements of the First Marine Division, Camp Pendleton, and the Third Marine Aircraft Wing, Marine Corps Air Station, El Toro.

The Fourth Brigade executed a tactical maneuver involving the helicopter lifting a reinforced infantry battalion in air attack to seize, occupy and defend an objective in exploitation of an atomic explosion.

A company of the battalion mobed to the ground objective mounted in LVTP5's - the Marine Corps' latest version of the amphibian tractor that stormed Pacific beaches in World War II. The armored monster is capable of bringing Marines ashore with dry feet, and then transporting them inland to their objective.

Supporting the amphibian-mounted company was a platoon of the Corps' newest anti-tank weapon - the Ontos - a small tracked vehicle with tremendous firepower.

Marine close air support was furnished by jet fighter aircraft based at the Marine Corps Air Facility, Mojave, California.

U. S. Air Force

Participation of the Air Force in Operation Plumbbob includes an important air support role, participation in experimental operations, and training.

Air Force participation in the air-to-air rocket experiment will include firing of the rocket from a manned aircraft, as well as support by innumerable types of aircraft from various Air Force commands.

Support activities include pre-shot weather missions, documentary aerial photography, radiological surveys, cloud sampling, cloud tracking, and air control. These activities are carried out by aircraft of the Air Research and Development Command, Tactical Air Command, Strategic Air Command, Air Training Command, and the Air Pictorial Charting Service.

Training activities include flights through the nuclear cloud by the Air National Guard and Air Defense Command for crew familiarization with aerial effects of atomic detonations.

The majority of these aircraft stage out of Indian Springs Air Force Base, Nevada, a unit of the Air Force Special Weapons Center at Kirtland Air Force Base, New Mexico. The Special Weapons Center, commanded by Brigadier General William M. Canterbury, is one of ten centers under the Air Research and Development Command, and has supported the AEC in both continental and overseas tests since Operation Crossroads in 1945.

13. CIVIL EFFECTS EXPERIMENTS

Civil Effects Organization

The Civil Effects Test Group of the Nevada Test Organization is sponsored principally by the Atomic Energy Commission and the Federal Civil Defense Administration, but other Government agencies, some private industrial groups, and two foreign nations have projects in its program.

The scientific and technical studies are comprised of ten programs, 54 projects, and about 200 shot participations involving individual experiments, and require at NTS a peak population of about 400 scientific and staff personnel. All projects are reviewed by appropriate scientific and technical test screening and planning committees before acceptance for field testing, and are coordinated with the military effects tests.

The Civil Effects Program stems from a continuing need for up-to-date information on the effects from weapons as they are developed. Continental test afford unusually good opportunities to verify in the field various theoretical concepts and laboratory programs which are directed toward complete knowledge of the possible effects of nuclear detonations on man.

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The six general areas of civil effects study in the Plumbbob program are:

(1) Fallout radiation
(2) Prompt-gamma and prompt-neutron radiation
(3) Blast effects on structures
(4) Blast biology studies
(5) Radiological countermeasures and training

Correlation of Biological Data

Considerable effort is being devoted in the 1957 series toward obtaining more information in field tests, through use of animals and various tissue-equivalent materials, which can be applied in determining the effects of radiation on man.

In the past, insects, animals and materials have been studied in laboratories and in the field to try to arrive at the probable effects on man. However, there are important differences in response to radiation exposure between the different species. Many of the differences are based upon size. There also are differences between laboratory theory or experimentation and actual experience in the presence of full scale nuclear detonations. More data has been obtained from laboratory work than from work done in association with nuclear detonations.

Experiments being carried out in Plumbbob have been integrated into a coordinated effort to fill out as far as possible the spectrum of desired effects data.

Robert L. Corsbie, Director, Civil Effects Test Group, has described the resulting coordinated project as one which does not cost 25 cents above the originally proposed activities, but which would cost more than a million dollars if planned separately.

The Franklin shot, second in the series, had associated with it an unusually broad program of experiments to help determine the acute and chronic effects of radiation exposure. Other experiments later in the series, including Wilson, were to be used to supplement the data obtained from Franklin.

Angular Distribution Studies are being conducted during the series through the use of collimators and greatly improved dosimetry to evaluate the radiation doses which would be received by individuals in locations shielded by physical structures or terrain.

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Shielding Studies: Among the Civil Effects Test Group experiments are a number to relate the angular distribution of neutrons and rays at various distances, as noted above, with the effects of shielding. Several of the experiments are designed to help further the investigations of the Atomic Bomb Casualty Commission, which began its work in Japan in 1946.

The ABBC files contain clinical records of more than 4,000 survivors. Information contained in the files would have more significance for radiation medicine if it could be related to the varying radiation doses received by the individuals under the known shielding conditions and distances that existed.

About 65 per cent of the survivors in Japan whose cases are adequately documented were shielded in light wood houses. Shielding studies during the 1957 series will involve construction of two light frame houses and the use of about five transportable light-weight construction buildings of a type used generally at the Test Site. All construction will be by American construction methods, using principally typical building materials. The houses are expected to provide enough similarity to Japanese or other light types of construction to result in scientific findings on shielding provided by internal or external walls, windows or roofs with relation to exposure in various portions of the structures.

To obtain the desired information, instruments will be placed at various locations within the structures. No animals will be used within the structures.

The shielding studies of geometrical configurations involving structures will be made quite late in the series.

The two houses to be used in the studies and which are to be erected at the Test Site will be essentially bare construction, using light wood in part and with a considerable wall area in windows. Southwestern American type adobe mud will be used for part of the construction. The transportable structures represent a variety of small, single room buildings such as are used commonly for construction offices, tool sheds, and field laboratories. They are made of light wood frame with typical wallboard, masonry or metal sidings, and with asphalt or asbestos shingle or tarpaper roofs.

Blast Biology

Further studies relating to blast biology are being carried out by the Lovelace Foundation and are directed toward obtaining more information on the primary, secondary, and tertiary effects of blast. They are a continuation of work begun during 1953-1955, where for the first time a means was devised of obtaining usable information on numbers and types of missiles (flying bricks, timber, glass, etc.) per unit area and on the penetrability of glass and masonry fragments and other small missiles likely to be produced in an urban area that has been subjected to a nuclear blast. It is expected that the studies during Plumbbob will provide equally valuable information on the problems associated with biomedical effects of static pressures and dynamic pressures sufficiently strong to translate bodies the size and weight of a man from a state of rest tc a state of motion.

Countermeasures and Training

One of the important new programs that will be initiated during Plumbbob is work by the Naval Radiological Defense Laboratory on countermeasures against fallout radiation. The proof-testing of radiological shelters and typical buildings is expected to produce data useful in practical applications and guidance for planning a long-range program on methods of survival and continuing occupation of areas that have been subjected to heavy radioactive fallout. This program is designed to provide confirmation and applicability of laboratory theories and methods of decontamination to the large-scale recovery of areas contaminated by radioactivity, and in addition to develop data on scaling from low yield to megaton detonations.

Animals Used in Experiments

In addition to pigs whose use in some experiments already has been described, other species of animals are being used during the series so effects of detonations on man can be determined. Animals such as mice, guinea pigs, monkeys, dogs and rabbits are used in such experiments.

Use of "Phantoms" in Biological Studies

During some tests of the series, including the Franklin shot fired June 2, depth dose studies with relation to gamma radiation are conducted using "phantoms" such as liquid or solid materials which approximate the densities of human tissues. Ordinary wallboard is one of the materials used.

14. FCDA PARTICIPATION

The nuclear tests held at the Nevada Test Site provide the Federal Civil Defense Administration with an opportunity to obtain vital technical and engineering information under conditions provided only by nuclear detonations.

Lack of sufficient land mass and the fact that climatic and geographic conditions are dissimilar to those in the United States make Pacific tests unsuitable for testing shelters and for radiological research and training. Therefore, while FCDA participates in Pacific tests, the bulk of its programs are scheduled in Nevada.

Civil defense participation in Operation Plumbbob falls into three categories:

(1) Conduct of research programs to develop technical information needed in civil defense. This includes the testing of

equipment and structures. These activities are conducted under the Civil Effects Test Group, in which FCDA is a principal participant.

(2) Training of specialists in various phases of nuclear defense activities, particularly in the radiological field.

(3) Indoctrination of key civil defense personnel and officials with civil defense responsibility and assisting in carrying out the civil defense responsibility for public education on nuclear weapons effects. These activities are largely conducted by the Joint Visitors Bureau, with civil defense having a large part in the justification, planning and conduct of "open" shots.

In Operation Plumbbob, for the first time, there is participation by the civil defense organizations of other nations. Foreign civil defense representatives have been invited to open shots and French and German shelter designs are being tested, under FCDA sponsorship.

FCDA has four large technical programs in Operation Plumbbob. Two of these programs are designed to furnish data for the Engineering Office and two are designed to furnish data and operational information to the Radiological Defense Division.

Shelter Tests

FCDA engineering programs are primarily concerned with obtaining criteria for the design of shelters -- dome, dual purpose and family type. Shelters of various types were constructed on Frenchman Flat so they could be subjected to a nuclear explosion. This is the "proof testing"; in other words the taking of the final step in design by subjecting the design to actual nuclear detonation conditions. (For some things, such as shelters, engineers often believe the results are predictable. Even so, since human lives are involved, actual field tests must take place.)

Two types of mass shelters were tested in Operation Plumbob. One is a dual-purpose shelter, designed for use either as a shelter or an underground garage -- a type of protection now being built extensively in the Scandinavian countries.

The other is the "dome" shelter which has been advanced in engineering circles as an effective and economical means of providing mass shelters. Dome structures are much cheaper to construct than other types and FCDA technicians are anxious to study how they will react under the pressures of an atomic explosion.

Tests were conducted on three reinforced concrete domes of 50 foot diameter and six inch constant shell thickness; and on one full-scale dome type steel shelter door $8\frac{1}{2}$ by $10\frac{1}{2}$ feet installed in a reinforced concrete structure.

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Originally it was planned to build one dome shelter 150 feet in diameter -- a size proposed by the designer, American Machine and Foundry Company, as most practical for this type. However, it was decided that the required engineering data for design, loading, response, and mode of failure, could be obtained from a 50-foot dome so instead of one 150-foot dome, three 50-foot domes are being tested at pressure ranges from 20 to 70 pounds per square inch.

The construction method for these shelters consisted of heaping up a dirt mound of the required size, covering it with the reinforcing steel, and then forming the concrete shell by the "shotcrete" method. After the concrete hardened, the mound of earth was removed and space under the dome became available for shelter and for instrumentation.

Although dome shelters could be constructed either above or below ground, all of the test structures were exposed to blast without the aid of earth cover.

The dual purpose shelter is of conventional underground design and was built at a cost of approximately $200,000. It is under three feet of earth and is approximately 90 feet by 90 feet. Access is gained by means of an auto ramp, with the longitudinal axis radial to Ground Zero. Closure is effected by means of a reinforced concrete door weighing approximately 100 tons, mounted on a monorail. The roof slab, two feet six inches thick over drop panels, is supported by nine columns on 29-foot centers and bearing walls.

FCDA tested three reinforced concrete family type underground shelters, at pressure ranges from 30 to 65 psi. The family shelter has been designed to provide nuclear blast protection and minimum living facilities for a group of approximately six persons. It is designed to withstand overpressures of 30 psi or more and reduce both the initial and fallout radiation to a safe level. This reinforced concrete shelter has an underground chamber seven foot square and six and one-half feet high, connected with the surface by a corridor containing two right angle bends and an inclined entrance-way where a steel plate blast door is located. It is also connected with the surface by a corrugated steel, round, emergency escape hatch which could be used if the entrance-way was blocked.

It is believed that the cost of finished and supplied shelters of this type would be from $1,800 to $2,500 in the average locality.

Foreign Shelters

Through the cooperation of AEC, the Department of Defense, and Department of State, FCDA was able to accede to requests from the French and West German Governments to test their shelter designs. The actual tests are being conducted by American contractor personnel acting as agents of the governments concerned.

Both the French and the German shelters are family-type structures. They are being tested at maximum pressure ranges far in excess of those used for testing the American shelters.

Nine German and two French shelters are being tested. In addition there are tests of three isolated entrance-ways of French design. One French shelter is rectangular and one is cylindrical, while seven of the German shelters are rectangular and two are cylindrical.

Vault Design Test

Another project, sponsored and paid for by the Mosler Safe Company, was a test of a reinforced concrete, steel-lined vault and a standard steel safe door. The vault, 11 feet by 10 feet by 17 feet, was fully exposed above ground. Closure is effected by a ten-inch thick steel door.

This test, to confirm the level of resistance of materials and structures to a nuclear blast at close range, grew out of the concern on the part of banks and insurance companies over protection of vital records and valuables.

The cost, in terms of overall research and construction, exceeded $500,000.

Air Zero Locators

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 were provided. Previous tests have demonstrated that a camera-type recording device is feasible. FCDA is financing the development of three different types of devices and numerous screen materials through the Eastman Kodak Company, the Bureau of Standards, and the Quartermaster Corps. Eighty prototype air zero locators are being tested under a variety of field conditions.

Masonry Construction

Unreinforced brick masonry structures were compared unfavorably with reinforced concrete structures in previous tests. The Structural Clay Products Research Foundation has developed a design which they claim is highly resistant to blast loads. This design and a number of wall panels were tested to determine resistance to nuclear blast, at the industry's expense.

Door Tests

This project is for obtaining criteria by which the design of commercial doors may be established for low blast pressures. Previous tests showed a need for reducing the damage to doors and eliminating the missile hazard resulting from doors becoming dislodged in low pressure blast areas where otherwise damage would be very minor. Doors and hardware have been designed utilizing commercial door manufacturers' components. Ten test doors were mounted in cells for this experiment.

Ventilation Equipment

This test was performed on several types and sizes of pressure sensitive and remotely operated anti-blast valves for ventilation openings. To prevent injury to occupants and damage to filters and other shelter equipment, blast resistant closures must be provided for all ventilation openings. Research and development on this project has been done under contract by Arthur D. Little, Inc. A total of eleven prototype valves were tested to obtain designs for rugged, reliable and quick acting blast valves of various sizes and overpressure ratings.

Radiological Defense

One program in the radiological field is designed to give the technical data necessary for the formulation of specifications for radiological instruments, establishing nuclear radiation shielding requirements, decontamination procedures and radiological monitoring techniques. A second program is designed to obtain information necessary for the formulation of radiological defense operations, techniques and philosophy. It also provides training in a contaminated field for state and local personnel.

The decontamination program is to evaluate the effectiveness and feasibility of various methods of decontaminating structures and areas. Methods used include flushing, covering, removal of earth, sweeping, etc.

This project also serves to demonstrate and train personnel in decontamination procedures and countermeasures.

Monitoring Techniques

Objectives of this project are:

(1) To obtain further experience for the purpose of evaluation of aerial, automotive, and ground monitoring surveys.

(2) To evaluate attenuation factors for mobile survey methods.

(3) To evaluate aerial equipment being developed for civil defense use.

(4) To obtain information on radiation exposures associated with such surveys.

Evaluation of Instruments

This is a continuing program designed to evaluate radiation detection instruments under field conditions. Both standard FCDA and other commercial instruments are being tested. Radiation instrument manufacturers are participating in this project.

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Field Operations

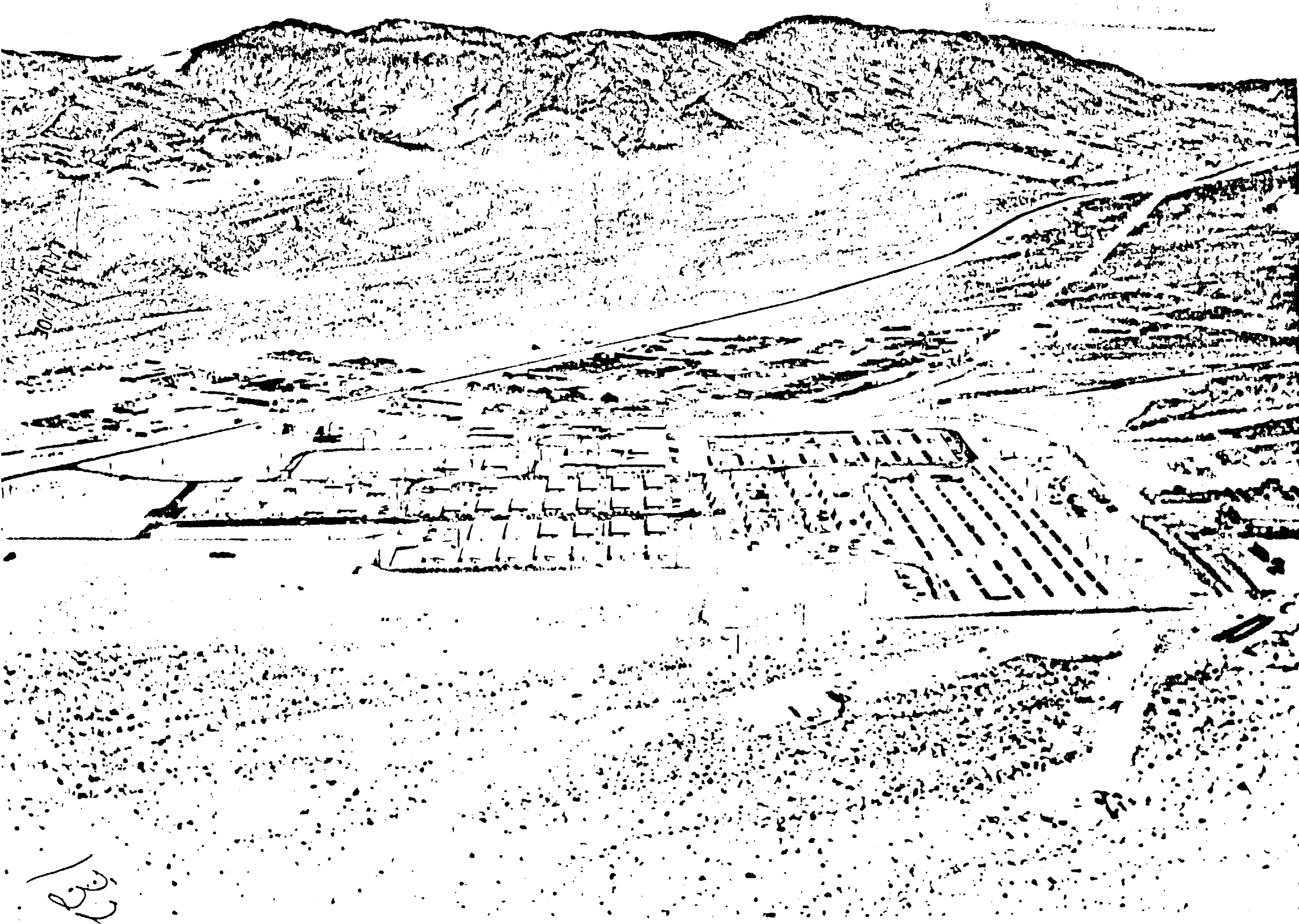
Under this project two different groups of approximately 40 representatives of various Federal agencies, and state and city civil defense personnel, are assigned to the Test Site for a two-week training course. The course includes briefings and lectures on survey and monitoring techniques and on activities at the Test Site. They will participate in installing and recovering instrumentation used in various radiological tests. They also will be given training in actual survey of areas contaminated by fallout and will visit AEC off-site monitoring stations to observe the activities carried on throughout the test series.

Another project, mainly under the sponsorship of state civil defense organizations, is designed to provide experience in and further the development of operational techniques and concepts in radiological defense. A group of 25 persons will work with some 30 members of the California Radiological Safety Division to conduct this project. Their activities will include on-site monitoring and training exercises, and they may also conduct an off-site training exercise, making surveys along the path of fallout clouds.

Support Participation

FCDA is also participating in three programs conducted by other agencies. FCDA is supporting AEC and the Department of Defense with funds and personnel in a study of blast biology. It is cooperating with the Naval Radiological Defense Laboratory in a program involving radiological defense countermeasures, and it is giving administrative assistance to the Food and Drug Administration on tests of foodstuffs.

NEVADA TEST SITE'S CAMP MERCURY



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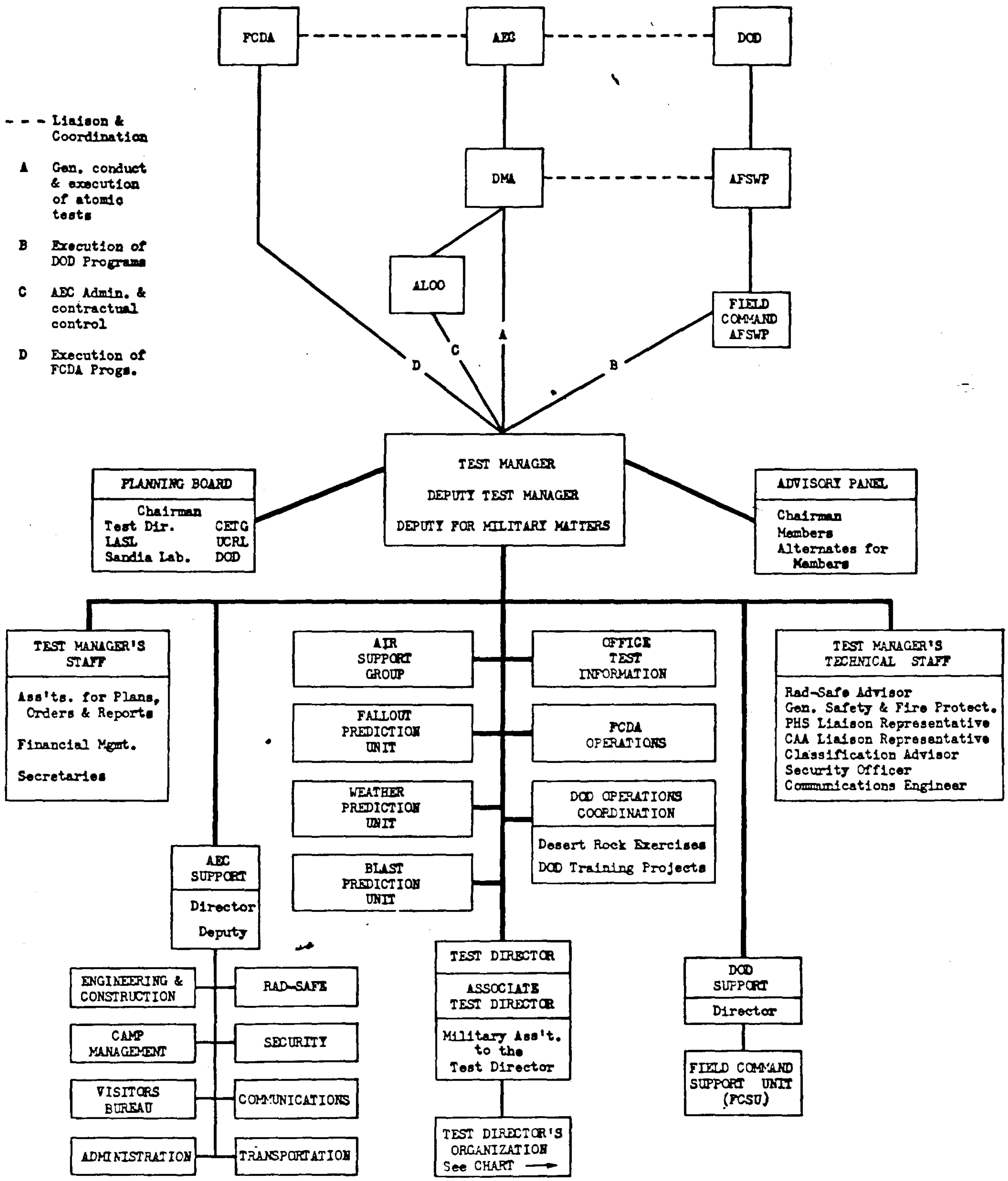
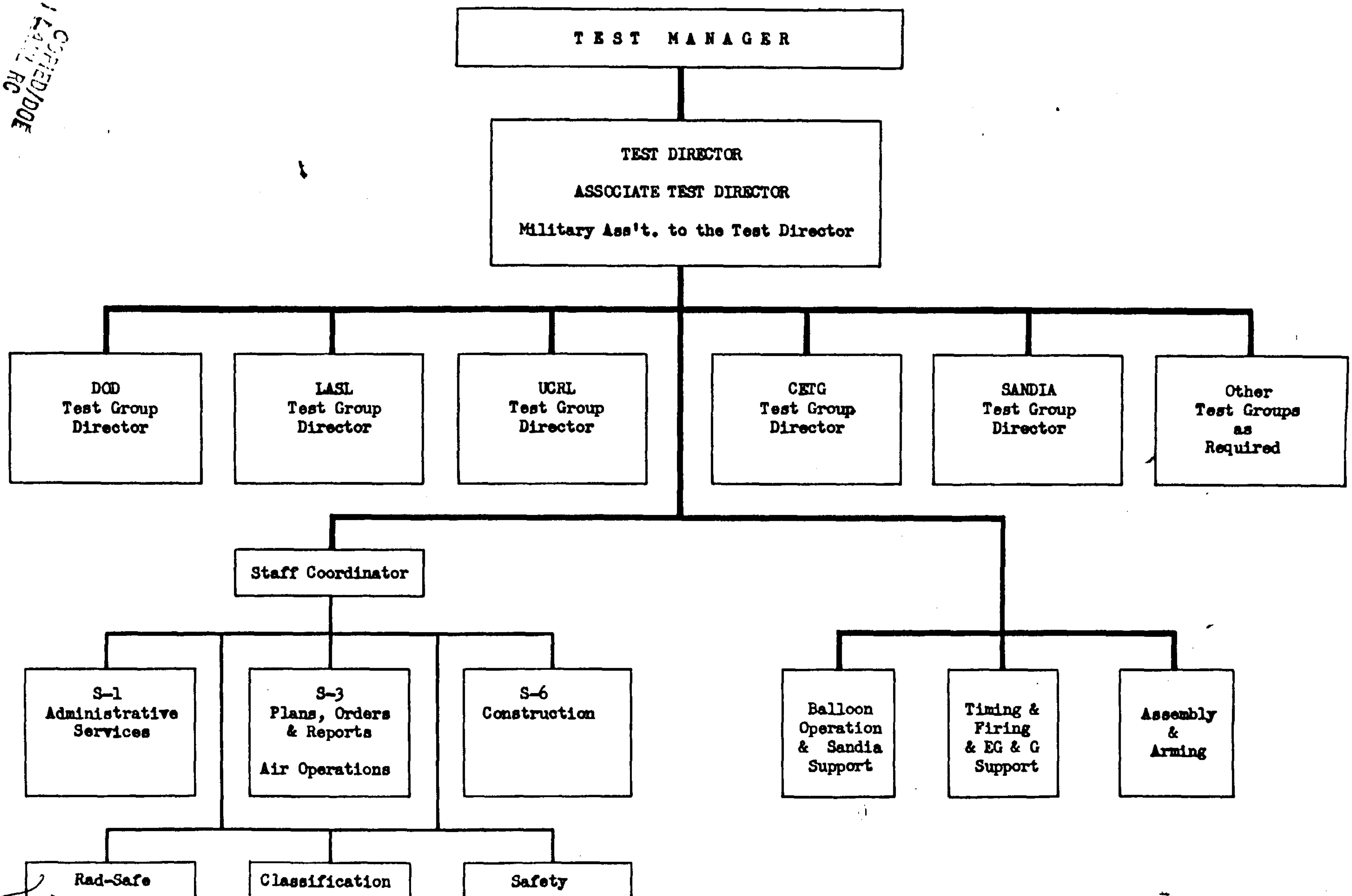
OPERATION OF NEVADA TEST ORGANIZATION

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TEST DIRECTOR
ASSOCIATE TEST DIRECTOR
Military Ass't. to the Test Director
DOD Test Group Director
LASL Test Group Director
UCRL Test Group Director
CETG Test Group Director
SANDIA Test Group Director
Other Test Groups as Required
Staff Coordinator
S-1 Administrative Services
S-3 Plans, Orders & Reports
Air Operations
S-6 Construction
Rad-Safe
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Safety
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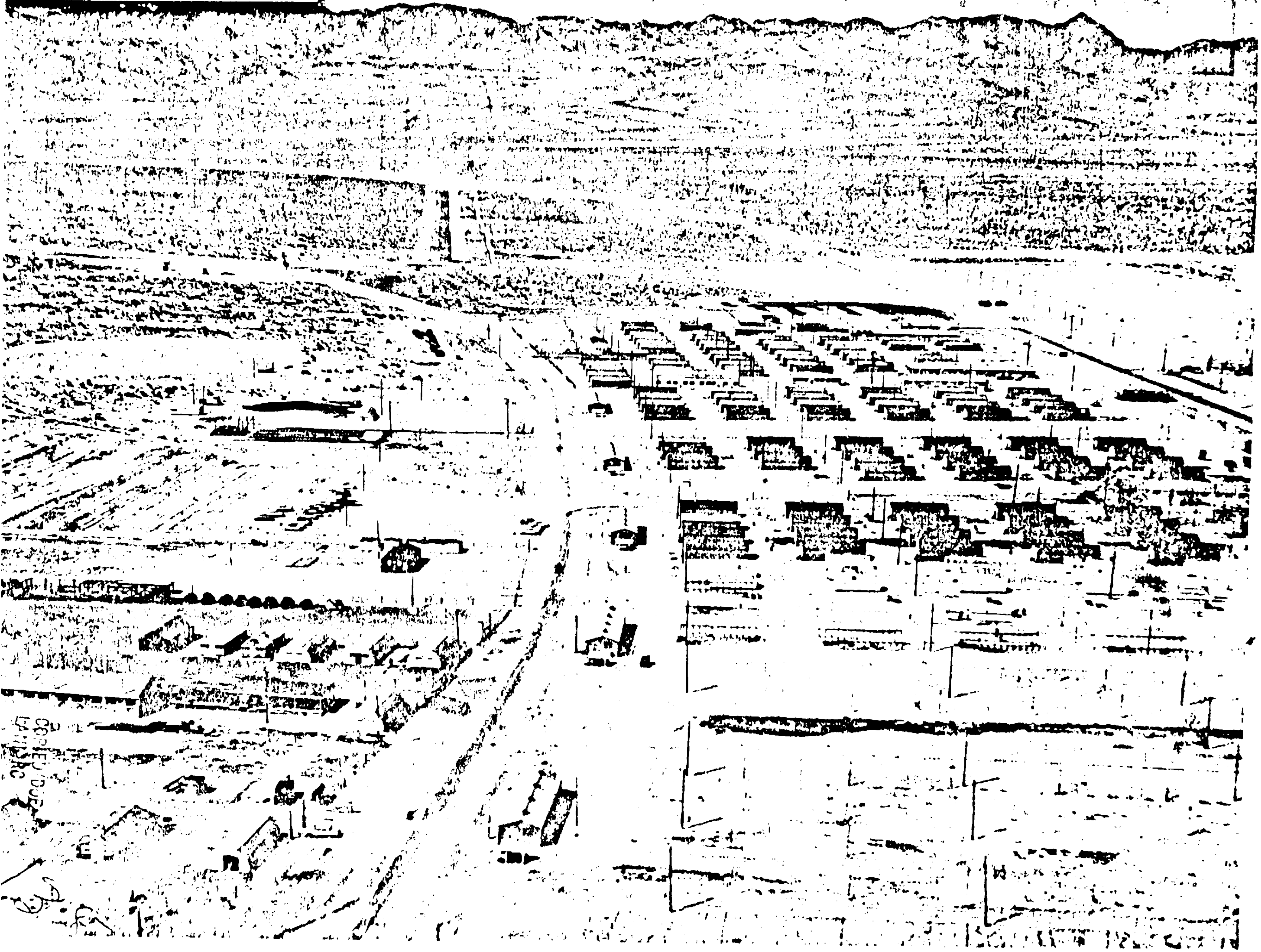

ERIAL VIEW OF CAMP DESERT ROCK