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NUCLEAR TESTING AND FALLOUT PROGRAMS AT THE UNIVERSITY OF CALIFORNIA LAWRENCE RADIATION LABORATORY

The Lawrence Radiation Laboratory-- Berkeley & Livermore.

During World War II the Radiation Laboratory, founded by Ernest O. Lawrence at the University of California in Berkeley, was mobilized to study the possibility of using uranium for military purposes. The Laboratory adapted the 184-inch cyclotron as a mass spectrometer (renamed the Calutron) to test the feasibility of separating fissionable natural uranium, U-235, from the more plentiful uranium isotope, U-238. Using University and Office of Scientific Research and Development (OSRD) funds, Lawrence first converted the 37-inch cyclotron to a test model mass spectometer for enriching uranium 235. In 1942, the Laboratory supplied the design and magnets for several Calutron-type separators at various laboratories and advised on the construction of an electromagnetic facility at Oak Ridge. Even earlier, beginning in 1939 and 1940, Laboratory studies of fission products revealed a new element, heavier than uranium, named plutonium, which suggested the possibility of an atomic chain reaction.

The Laboratory sent the weapons-grade U-235 produced from beta calutrons to Chicago and on to the Los Alamos laboratory. The University of California provided the administration of the Los Alamos laboratory as well as staff from the Radiation Laboratory who assisted in the design and execution of the Trinity test. Wartime mobilization also stimulated the study of physiological effects of fission in the Laboratory's Biology and Medicine and Donner Laboratory as researchers studied the biological effects of fission products for the OSRD.

After the war, the AEC took charge of the nuclear energy program in 1947. The Radiation Laboratory's defense work centered on the separation of fissionable elements. The Laboratory continued to conduct multidisciplinary scientific research, including AEC support of nuclear chemistry in identifying transuranic elements.

The Donner Laboratory continued its prewar work in nuclear medicine and radiology. Between 1946 and 1949, the military programs of the Laboratory were focused primarily in the Crocker Laboratory, under the direction of Joseph Hamilton. In 1946, Laboratory radiobiologists participated in the Bikini tests and advised the Navy on decontamination of ships exposed to nuclear explosions. The Crocker Laboratory studied the biological effects of radioactive aerosols and fission products.

After the Soviet detonation of a nuclear bomb in 1949, the Laboratory-- led by Edward Teller and Ernest O. Lawrence -- campaigned for a second national nuclear weapons laboratory at

Livermore. The Laboratory began to support a program for a-thermomonuclear weapon or superbomb. The Laboratory also began a project for a prototype accelerator, Mark I, after the President's decision to pursue the Super in 1950, and to design a production machine, Mark II. Mark I was designed to produce polonium for weapons and radiological warfare while Mark II was designed to produce tritium and plutonium.

The reorganization of the AEC in the 1950s led to the support of environmental research and non-nuclear energy development. The Berkeley Rad Lab began new programs in energy, environment, earth, and other sciences, nuclear waste disposal, and investigation of geothermmal energy, as well basic physical and accelerator research. In contrast, the Livermore Laboratory was established to develop the Super Bomb and the Mark series of production machines (code named Material Testing Accelerator or MTA) for use in the weapons program and radiological warfare.

In 1952, the AEC established the Livermore laboratory as a branch of the Lawrence Radiation Laboratory, an administrative arrangement which lasted until 1971. This arrangement allowed the Berkeley laboratory to concentrate on basic nuclear research and reduced classified research there. Livermore took most of the Radiation Laboratory's work in applied science, including nuclear weapons development and the nuclear rocket project, Pluto; the peaceful application of nuclear explosions, Plowshare; and the Sherwood Program for controlled thermonuclear reactions.

In 1955, the AEC acquired Site 300, located fifteen miles east of Livermore, as a staging ground for Livermore's non-nuclear tests. During 1956-1960, Livermore was assigned the crash program to design a new warhead for small, submarine-launched nuclear missiles, Polaris. In 1957, Plowshare began as a multifaceted effort, stemming from discoveries of underground nuclear bomb tests for excavation, geological research, gas and oil extraction and storage. The declassification of Project Sherwood in 1958, opened up research in non-explosive fusion energy.

In 1960, Livermore's computer facility began major expansion-in order to "simulate" nuclear tests during the 1958-1961 nuclear moratorium. The Biomedical Research Program at Livermore was established in 1963, under John Gofman (of Donner Laboratory), to study the effects of radioactive fallout on humans, and later expanded to study the possible harmful effects on all biological systems. LRL conducted non-nuclear tests at Site 300, both nuclear and non-nuclear tests at NTS, and participated in test operations at PPG. In 1971, Livermore was officially made a separate national laboratory from Berkeley.

LONG-RANGE PROGRAMS

Biology and Medicine Division -- Berkeley;
Biomedical Program--Livermore

The principal goal of the Biology and Medical program of the Berkeley Laboratory has been to explore the effects of irradiation on biological systems and to learn about the basic events through which radiation causes biological change. The protection of biological systems against the detrimental effects of irradiation was an integral part of the endeavor.

Biomedical projects included the study of irradiations on tumor growth and the problems of fallout. An important result of the studies of strontium-90 metabolism and turnover in human bone was the establishment of a quantitative estimate of fallout radioactivity from the Soviet test series of March-April 1958. After determining West Coast contaminants from fallout, measurement of radioactivity in foodstuffs led to estimates that contaminants were within limits of tolerance. The measurements also provided a guide to exposure from short-lived radioactivity associated with prompt fallout.*

Biology and Medicine focused study primarily on the effect of accumulated radioactive substances in the body and their deposit within specific tissues. These studies provided a basis for establishing levels of maximum permissible exposure. Investigations were made of the metabolism and pathological effects in laboratory animals of radioactive isotopes of strontium, calcium, radium, lathanide and actinide groups of elements; acute effects of massive doses, including mortality; long-term effects of relatively low dosage, including life-span shortening and elimination time of tracers, in an effort to correlate damage with absorbed radiation.

The availability of the 184 synchrocyclotron, the heavy-ion linear accelerator (HILAC), the Bevatron, and the linear pool reactor at Berkeley in the late 1950s and the 1960s offered instrumentation for investigating the biological effects of irradiations on the blood-forming system and of anemias produced by radiation and by disease. Biology and Medicine placed in operation whole-body counters (in which the person is entirely surrounded by radiation detectors) to provide a means for determining the amount of radioactivity in the human body. The Personnel Dosimetry Office, assisted by Biology and Medicine, continued to provide film dosimetry and radiation monitoring for the health and safety of Laboratory staff.

* More recently the Laboratory conducted sampling in the San Francisco Bay region after the fallout at Chernobyll.

The Laboratory's efforts in the early 1960s were directed toward understanding injury due to ionizing radiation. The Radiation Laboratory began the use of radioisotopes regularly in the treatment of disease in 1936. Of particular interest was the study of any delayed effects of radiation and the incidence of cancer. The genetic and subcellular effects of ionizing radiation were also studied.

The Berkeley Health Physics Group conducted regular procedures for collecting and analyzing radiation samples of the Laboratory accelerators, using various neutron detectors and monitors. An extensive series of measurements were made at the NTS during Project Bronco to provide better estimates of the radiation exposure due to neutrons at longer distances from the source.

Beginning in 1963, the Livermore Biomedical Program investigated the effects of radiation on humans. A major effort was the development of theoretical models to describe the behavior of chemical elements in biological systems and the development of computer systems to process and analyze such data. In the late 1960s, the Biomedical Program began the study of radiation on DNA molecules.

Plowshare Program

The Plowshare Program was conceived and initiated at the Lawrence Radiation Laboratory during 1956 and 1957. The Laboratory explored the use of nuclear explosions for earth-moving excavations and other engineering projects. At the time the program was initiated, possible industrial applications centered around excavation since a number of craters had been made previously--one up to 1,000 feet in diameter in the atoll reefs of the Pacific test site. Scientists and engineers envisioned nuclear excavation as a possible method for constructing harbors and canals, including a harbor site in Alaska and canals across the Panamanian isthmus. Scientists found that explosions conducted underground generated large permeable zones which provided possible applications for waste disposal, oil and gas storage, aquifer recharging, gas and oil stimulus, and recovery of geothermal energy.

A few nuclear tests were conducted in basalt and desert alluvium. In July 1962, the Plowshare program carried out a 100 kiloton (kt) event in alluvium at the NTS. Three nuclear cratering experiments were conducted at NTS in this period: Cabriolet in hard rock, Schooner, and Buggy, the first detonation of a row of nuclear charges to excavate a ditch. The greatest problems with cratering were the stability of the resulting slopes and radioactive fallout. In the 1962 shots, experimenters were able to reduce the amount of fallout released to the atmosphere from the earlier (Cabriolet) to later (Danny Boy) shots. As a basic part of the Chariot experiment for excavation of an Alaskan harbor, the testers decided to establish all radiation backgrounds associated with plant and animal welfare before the test took place.

On September 19, 1957, in the test series Plumbbob, a nuclear test device with an energy release of 1.7 kt was fired in a tunnel under a mountain at the Nevada Test Site. The Shot was named Rainier. The test objective was to to develop a weapon testing technique which would eliminate fallout; be independent of weather conditions; and have no off-site effects such as noise, flash, and shock. The principle problems of the test concerned the depth necessary for containment of radioactivity, the magnitude of the induced ground motions and their effects on local and off-site structures; and the possiblity of ground-water contamination. Before the Rainier Shot the Test Division at Livermore made a study of the concept and feasiblity of underground testing in Spring 1956.

LRL created a motion picture film on the proposed uses of "atomic weapons" in the UCRL Plowshare Program for presentation at the Geneva Conference on Peaceful Uses of Atomic Energy in September 1958. Plowshare obtained increasing importance at the Laboratory by the late 1950s and throughout the 1960s.

The Plowshare work at the Livermore Laboratory was done primarily by K Division, but A and B Divisions (Weapons and Devices) designed nuclear explosions specifically for Plowshare use. Chemistry Division performed the radiochemistry and physical chemistry parts of the program. L Division (Test) completed field experiments, and the Physics Department assisted in long-range code development for equation-of-state work. By using these techniques, the laboratory calculated shock waves and cavity explosions of earth materials in bedded salt (Gnome), granite (Hardhat), dolomite (handcar) and salt dome (Sedan). The Laboratory developed special calculation codes, TENSOR and PUSH for duplicating observed high-explosive and nuclear exposive cratering. Nuclear debris was recovered by drilling, and samples were analyzed at Lawrence Livermore for isotopes produced by neutron capture in uranium targets.

Some Plowshare experiments were directed toward the use of nuclear explosions to produce heavy or transuranic elements. These tests involved exposing the target to intense neutron flux produced by the detonation. Following the neutron exposure, a series of beta decays occurred in chain and produced isotopes of elements with higher atomic numbers. Such a target under neutron exposure was equivalent to irradiation in nuclear reactions. This method was used, for example, in the Mike event at Eniwetok in 1956. The debris from the explosion was rich in transuranium elements, including einsteinium and fermium plus isotopes of plutonium, americium, curium, and californium.

The goal of the isotope production program was to design a nuclear explosion that would produce an intensive neutron flux in the heavy-element target, yet have a yield low enough to be fired successfully underground. In November, 1962, a thermonuclear device was fired underground at NTS as the Anacosta Event. Debris from such events was obtained by drilling into the shot region, and samples were sent to Argonne and LRL Berkeley for plutonium mass-spectrometry. Experimenters also studied strong shock waves from the underground explosions waves. Developing means for predicting shock was an important part of the Plowshare program at LRL.

The first nuclear excavation experiment in the Plowshare program was Project Sedan, conducted in July 1962 at NTS, using 100 kt thermonuclear explosive device at 635 feet in desert alluvium. Sedan was designed to provide data on cratering effects and on safety problems related to radioactivity, seismic effects, and air blasts.

The objective of the LRL Plowshare aspect of the tests at NTS was to determine the cratering characteristics of nuclear explosions in hard, dry, inert rock (such as basalt); to determine the amount, distribution, and decay of radioactivity released by nuclear cratering; to obtain data on shock pressure, seismic shock at various regions, and air blasts. In 1972 Project Plowshare ended after several large-scale underground nuclear explosions resulted in public and political opposition.

Sherwood Program

The Radiation Laboratory at both Berkeley and Livermore conducted extensive research in controlled thermonuclear (fusion) power. The Sherwood Program involved extensive communication among the principal laboratories at Los Alamos, Princeton, and Oak Ridge, and the two UCRL sites. The objectives of the program were to provide (1) a magnetic field configuration capable of containing plasma of ionized gas, either deuterium or deuterium-tritium mixture, and (2) a means to produce ionized plasma and heat it to very high temperatures. The program included the examination of the basic properties of high-temperature plasma, probing by electron and neutral atom beams, and measurement of x-rays and particles emitted from the plasma. To combat the serious effects of high-atomic number contaminants.

By 1963, the Berkeley Sherwood Program had begun to decline . At Livermore, efforts continued with investigation of aspects of plasma confinement for controlled thermonuclear reactions. Several devices were designed and operated at Livermore for these tests-- Table Top, 2X, magnetic mirror machines, Alice, and Astron.

Pluto Program

The Pluto tests facilities at Site 401, at Mercury, Nevada, included three areas: Hot Box, Blow Pipe, and Tory II A. The facilities group included operations for control and maintenance of the reactor, the test bunker where the test was performed two miles from the control point, the disassembly building where the reactor was dismantled after a run and environmental effects were observed. The Facilities group maintained all power systems. The Controls Group designed electronic controls, performed environmental tests on equipment. The Instrument Group specified instruments to be used, and evaluated and selected equipment.

Whitney Project

The Whitney program ws concerned with the design of nuclear explosives for national defense. Weapons design research included the investigation of basic processes of nuclear explosions and their effects.

LRL-Nevada

The Nevada Test organization of Lawrence Radiation Laboratory grew from 18 to 43 (in 1959) to 161 (1961) and, in 1962, 233 permament employees. The Nevada group was largely directed to the Pluto projects. These included the facilities and testing of the Tory IIA-1 reactor, devising a perimeter radiation monitoring system, and remote handling equipment. Personnel expansion in 1959 was in support of Hardtack II and the development of diagnostic equipment for underground tests after the moratorium. The Nevada organization provided support for projects carried on at NTS such as Hobo, Lollipop, Stardust, Tattoo, Rowboat, Scooter, Buckboard, and Stagecoach.

In 1962, the Nevada operations group supported the Laboratory's portion of the Nougat Operation. The Earth Science Group made measurements of underground shot phenomena as temperature, radiation, geological and physical properties. The TV camera system was modified to take pictures of the Gnome activity. Nevada Operations sampled and conducted measurements, mapped, and interpreted core samples of the Hardtack Neptune event, and developed a complete time and remote-area radiation detection, monitor display and recording system.

The suspension in October 1958 of all further nuclear testing for an indefinite time altered the immediate outcome of the experimental work of the Nevada Physics division. At the same time, the development of nuclear weapon designs during the moratorium continued. At the NTS, the Physics Group made diagnostic assessments of underground shots, including seismic effects, temperature, radiation measurements, and geological and physical effects of nuclear blasts. The Physics Group also calibrated and operated the Slifer System (Shortened Line Indicated Frequency

End Resource) for each nuclear test as well as studies of the seismic effects, temperature, radiation, and geological and physical effects of nuclear blasts.

Radioactive samples from NTS were usually sent to the Radiochemistry Laboratory in Livermore. The LRL Earth Science Group assisted in selecting sites, sampling, determining depths, interpreting gamma logs, selecting sampling techniques, geological mapping of excavations, and determining radioactive samples to be sent to Radiochemistry. (These included samples from Hardhat, Danny Boy, and Sedan, the first nuclear cratering under AEC Plowshare). LRL-Nevada also constructed and tested "Fran," a fast burst reactor used for irradiating special samples at NTS.

In the mid-1960s, the Laboratory Field Operations conducted several underground test series at NTS. The Chemistry Department developed an air-launch rocket sampling system to obtain samples of radioactive debris. The L Division developed rocket-carried instrument packages for device diagnostics. In conjunction with Sandia Corporation, the Division created booster and recovery systems. In the late 1950s and in the 1960s, the Test Division focused on the underground nuclear explosions for military use. A particular challenge in the test emerged in the recovery of test devices which measured phenomena in the presence of high radiation backgrounds.

In 1963, the Storax series of underground nuclear tests were made at NTS. LRL also designed and executed projects Schooner and Dribble salt dome shots.

By the mid-1960s, the LRL-Nevada Group averaged 250 people. They participated in Niblick and Whetstone weapons series, K Division Plowshare programs at NTS, Project Pluto Tory reactor series assembly, test, and removal; off-site technical and administrative support of projects; and the Airborne Diagnostics Program.

Engineering and Construction participated in construction of radioactive containment. The group also supervised deactivation of the area 401 Tory II-C reactor facility, constructed a mechanical and technical shop, the Super Kukla, and other facilities at NTS. In 1965, the Nevada Test Division moved into the "Blue Building" at Mercury which housed the Health Physics Laboratory, Photo Laboratory, Electronics and Mechanical Shops, and an IBM computer.

Both Physics and Earth Science at Nevada operated the Super Kukla and Fran reactors to test performance and measure effects. They also supported Weapons and Plowshare programs in the study of shock, geological and physical properties, and collected radiation samples. The Geophysics Section used diagnostic trailer for preshot seismic exploration and ground-motion studies from the shot, and airborne radioactivity tests. Electronics Engineering supported reaction history data acquisition, and operated and maintained electronic systems for B Division, Health and Safety radiation monitoring, and the Tory II- A and C, and Super Kukla reactor controls; and operated the telemetric system of data transmission. The LRL Electronics Shop at Mercury, Nevada, maintained test equipment and fabricated new special systems such as remopte camera and photo control, Sky Scan (airborne activity) and Vidor systems.

The Health and Safety Group of LRL- Nevada Operations supported all weapons tests and Plowshare devices, site emplacement, drilling and sample reading, and monitoring, control, and shipment of radioactive materials originated at the NTS. Hundreds of technical and nontechnical reports describe the Group's efforts. The Group sought to employ improved methods of radioactive sampling and analysis then available. A gamma spectrometer telemetry facility was installed in 1965 at Mercury for radioactive identification of recovered sample materials.

Pacific Proving Ground (PPG)

LRL staff participated in the Bikini shots of 1946 and several subsequent tests in the later 1950s up to the moratorium of 1958-1961. The resumption of weapons testing had an important impact on all divisions. In 1962 Dominic involved high altitude rocket drops and air drops at Christmas Island and air drops near Johnston Island. During Dominic, LRL personnel were stationed on Christmas and Johnston islands, as well as Oahu and Kauai in Hawaii. Staff accumulated data on nuclear detonations using diagnostic systems. Studies were also made of long-flight and high altitude weapon explosions for measuring high-energy neutrons.

Nuclear Testing Activities of Laboratory Divisions and Groups 1951-1971

PHYSICS

Experimental Physics & Weapons A Division- Livermore

The primary work of the Experimental Physics A Division was nuclear explosive technology which included the design of nuclear devices, weapons for military use, nuclear assemblies for industrial use (such as excavation and energy production), and developing sources of neutrons and isotopes for scientific experiments. A Division physicists worked in hydrodynamics, radiation and neutron transport, and thermonuclear reactions under steady and transient conditions.

As part of the Plowshare Program, A Division also designed special nuclear explosives for industrial uses and scientific experiments, and for predicting the effects of nuclear explosions in excavating, rock crushing, forming caves, and storing energy.

The Livermore Laboratory established an extensive testing facility for testing and developing high explosives at Site 300. The A Division experimental group used the explosive shocks from high-explosives and nuclear detonations to study the electronic properties of compressed materials. Physicists measured neutron cross-sections, determined equations of state of materials after detonations, and developed new tools for gathering data on the effects of nuclear explosives. With the end of the nuclear moratorium and the U.S. resumption of tests at both NTS and PPG, A Division began a six-day work week in 1962.

After a test series at NTS or PPG, physicists correlated the diagnostic results with their calculations and correspondingly modified and improved the technology with these results. The actual development of nuclear devices involved a large cross section of the Laboratory, including B Division, Chemistry, Mechanical and Electronic Engineering, Theoretical and Computation Divisions, and various support units.

Experimental Physics B- Livermore

Experimental Physics B conceived, designed, and conducted the experimental testing of special nuclear warheads and developed nuclear devices for the peaceful use of atomic energy. Physics B conducted nuclear explosions at both the NTS and Eniwetok Proving Ground to coordinate experimental and theoretical work.

By the late 1950s, B Division consisted of a number of small teams made up of theoretical and experimental physicists who developed particular devices. Engineering Support was assigned directly to the device teams. These teams were supported by Automatic Computing, Nuclear Diagnostics, and Chemistry, as well as outside laboratory and construction facilities. Theoretical and experimental physicists and engineers worked as teams to solve problems of time-dependent neutronics and shock hydrodynamics. These problems were studied experimentally by using diagnostic facilties and computer equipment at the Laboratory, including high-energy x-rays (from the linac), fast-pulsing low energy x-rays, high speed optics, electrical pin techniques, and radio-frequency detection systems.

In conjunction with the the effort on devices, physicists studied the general electrodynamic activity of explosions, new neutron sources and transuranic elements, atomic properties, shock dynamics, material states, and electromagnetic systems. Experimenters checked the performance of non-nuclear devices at Livermore's at Site 300, followed by a nuclear test at NTS. B Division Physics was responsible for the LRL tests fired at NTS. The division also operated the Super Kukla burst reactor at NTS.

In the late 1960s, atomic, nuclear, and solid-state physicists were also involved in the Advanced Space Nuclear Program with its objective of developing high-temperature reactions to generate substantial electrical power in space. The program emphasized reactor neutronics design, radiation effects, and advanced methods of power conversion. In effect, the weapons design amd other nuclear power programs stimulated research in physics and, in turn, physics stimulated developments in nuclear device designs.

ENGINEERING

Various project teams provided civil and mechanical engineering support to testing, including selecting and preparing sites, field placements, designing environmental control structures to withstand seismic and shock waves from explosions, designing and preparing diagnostic instruments to analyze the performance of devices, and perfecting firing systems, as well as piping and hardware to prevent radioactive materials of underground shots from reaching the surface.

Mechanical Engineering- Livermore

Mechanical Engineering supported the Weapons Division, Pluto programs and nuclear testing. Engineering worked on infrared detector systems capable of observing and recording shock waves. Reaction History Group developed telemetric methods for data collection near the signal source and rapid conversion into digital code for transmission to recording stations. Such units were tested in Operation Tattoo at NTS. High-speed time methods were also tested. The Reaction History Group also assembled systems to make neutron measurements in the Gnome-Plowshare Program.

For the Plowshare Program, a team of LRL Mechanical Engineers developed methods for sealing off underground nuclear test holes to contain radioactive materials. The engineers designed and installed a fast-acting valve to withstand high temperatures, pressure, and shock at the Mercury site.

Device Engineering- Livermore

Device Engineering provided mechanical enginering support to both A and B Physics Divisions for developing nuclear devices. Several of the experimental assemblies were designed and detonated at Site 300 to obtain hydodynamic data and to study the device performance. Device Engineering also adapted various special materials, including high explosives, fissionable and fusionable nuclear materials, and unique metals and plastic-metal compounds and their properties, to meet specific device designs. Ultimately, these design assemblies were detonated at the Atomic Energy Commission's proving grounds.

Device Engineering participated extensively in several full-scale nuclear tests operations, including Plumbbob and Hardtack II at the NTS, Hardtack I at the PPG, specialized Plowshare research, Operation 58A at Nevada involving nuclear safety experiments, and the 1962 Danny Boy shot, a low-yield cratering experiment conducted by the Department of Defense at NTS. Engineering also introduced two new methods of device placement--balloon and underground-- in the Plumbbob series.

In support of Plowshare, Device Engineering designed and built mechanical, electrical, and chemical explosive systems to study shock waves and effects in various rock media. The division measured ground shock pressure and shock wave velocity for several nuclear events at NTS.

Weapons Engineering- Livermore

The function of Weapons Engineering was to link the devices designed by A and B Physics Divisions to the final weapons and tailor weapons to the requirements of particular aircraft, missiles, and warhead design. The design, development, and performance of nuclear weapons rested with the AEC weapons laboratories-- Los Alamos and UCRL-Livermore, and supporting Sandia operations in Albuquerque and Livermore. When the Department of Defense, with the concurrence of the AEC, assigned responsiblities for warheads to the Livermore Laboratory, Weapons Engineering Division organized a project engineering team. LRL A and B Physics Divisions and Sandia Corporation Livermore Laboratory established working groups to coordinated the efforts of the two laboratories.

At Site 300, Device and Weapons programs conducted high-explosive experiments and tests. Diagnostic information obtained from the explosions included pin technique (using electrical pins and special oscilloscopes), fast photographs (using framing and smear cameras), and linear accelerator methods.

Electronic Engineering- Livermore and Berkeley

Electronic engineers designed, installed, and operated the instruments used to make diagnostic measurements of nuclear explosions, including elaborate instrumentation complexes for data transmission and radiation detection. Electronic Engineering designed and developed the electronic equipment for the thermonuclear reactors and devices, superconducting magnets systems to measure temperature and magnetic fields, and environmental control facilities. For many tests, Electronics designed, installed and operated the instrumentation in the test bunkers, mobile trailers, and aircraft. The division developed seismometers for recording movements resulting from underground nuclear explosions, earth movements, and pressure studies under the industrial Plowshare program.

The Berkeley Electronics Engineering Division developed the neutron counter instrumentation for use in the Atlas Missiles. Berkeley then turned it over to the Livermore Laboratory for completion. Electronics also devised automatic counters for air-sampling for Health Chemistry. The Livermore Electronics group developed fast data-reduction and telemetry systems to replace expensive and large coaxial cable for transmitting nuclear reaction data. They designed analog computer systems to measure shock and vibration data, oscilloscopes, and automatic film scanners. For the Pluto Program, they designed and installed instruments and controls for high temperature tests of materials and the "Hot Box" at NTS (See R Division).

At Livermore, the Division utilized LRL's computer complex for the analysis. evaluation, and design presentation of weapon tests. In conjunction with the Test Division, Electronics created fast response weapons detectors, including a system used for reading photographs of oscilloscope tracers, photodiode and Cerenkov detectors, and computerized film.

R Division- Livermore

The Livermore R Division developed nuclear reactor for a ram-jet engine--Project Pluto-- and conducted basic reactor research and development. R Division used the computer neutronic codes, ANGIE and ZOOM, measured criticality of assemblies, and correlated theoretical calculations with experimental data. At NTS, LRL constructed a research facility for the study of the neutronic characteristics of critical assembly at high temperatures. This device was named the "Hot Box." and helped to normalize codes and extrapolate operating conditions for the first engineering test reactor, Tory II-A.

Test Division-Livermore

The Test Division performed diagnostic measurements of experimental nuclear devices leading to the design of more efficient nuclear weapons. Using nuclear emulsions and threshold detectors, the Division measured neutron yields and spectra. Using optical and electronic transmission and recording methods, Test Division measured the variations in time of prompt radiations.

For Operation Plumbbob in 1958, a high-quality optical transmission system was developed to replace the use of large coaxial cable. This optical system conveyed the light signals produced in plastic scintillators by various nuclear radiations from the shot tower to photoelectric detectors to recording oscilloscopes placed in the electronics bunkers. Light signals were recorded by means of fast photographic techniques. The Test group made observations of surfaces made extremely hot by nuclear detonations and of the "Teller Effect," or glow produced by gamma radiations with the air. The Test Division also recorded light signals by using streak cameras capable of resolving time differences and framing cameras capable of making photographic records at a rate of 3 million per second. Time-dependent nuclear radiation events were measured by converting prompt radiation signals into electrical signals displayed and photographed on oscilloscopes.

In Operation Hardtack I, Test Division utilized computers at the test site to generate accurate field-data reduction. Detection was advanced by use of Cerenkov radiators as the detection medium which recorded gamma signals in the presence of high neutron background. To provide necessary shielding from both gamma rays and neutrons a composite shielding material consisting of homogeneous mixture of lead and paraffin was created. Photograph emulsions were used to measure neutron yield and spectra and to determine energy distance by measuring recoil protons. The neutron energy threshold was measured by activation in threshold detectors. Several days after exposure, the induced radioactivity was determined by counting and autoradiography. In Hardtack I at PPG, experimenters placed the threshold detectors under water near the nuclear explosion. In the Plumbbob series, they developed a system for making threshold neutron measurement by time-of-flight technique and electron recording.

Working within the recommendations of the President's Panel on Seismic Impression, the Test Division planned and operated test projects at both the NTS and Winnfield, Louisiana. Project Lollopop at NTS was a plan to detonate a nuclear device after the moratorium at a proper depth and location with seismic recording instruments. The Winnfield test, named Project Cowboy, used conventional explosions in a salt dome. Plowshare Program projects of the Test Division included Chariot, a nuclear detonation within a salt bed in southeast New Mexico; Vintage, designed to extract oil from shale by nuclear explosion; and Project Oil Sands to extract oil in Canada. Subway and Oxcart were designed for study of previous bomb craters.

With the resumption of nuclear testing, the Whitney Reaction Test History Test Group utilized telemetry to make data available immediately after a nuclear shot, replacing the recovery, development, and reading of film. The Test Division continued however to make broad use of oscilloscopes and recording cameras.

Test Operations Group- Livermore

The Test Division was supported by Test Operations Group. The Group was comprised of the Field Services Unit, L-4 shipping and warehousing unit, and L-6 engineering and construction group. In 1958, Field Services consisted of five staff members augmented by four military personnel. They, as a group, were responsible for collecting and consolidating all the requirements for operational support and administration, including housing, transportation, communication, badges, office space, and equipment, with LRL administration. Field Services took part in nuclear tests and Plowshare projects, including Hardtack I (PPG) and Hardtack II (NTS). With further testing discontinued by moratorium, Field Services engaged in nonnuclear Plowshare testing. Staff to handle these responsibilities were assigned to the islands of Fred and Parry on Eniwetok and Nan and Peter-Oboe on Bikini. More personnel were required for zero-site barges and ship assignments during periods of evaculation. For Hardtack I in PPG, ten men arrived from Livermore and Berkeley to expand the permament staff at the site. At the same time, Field Services staff prepared for Hardtack II at NTS. Operations were similar to those at PPG except that support administration was the responsibility of the LRL-Nevada organization. LRL- Nevada also prepared and published the test schedule, issued two days prior to each LRL shot.

The L-4 Section obtained, packaged and shipped all user-furnished equipment to support the Laboratory in the field, stored and distributed this material and returned it to Livermore. Five staff members completed this assignment in 1958.

L-6 Section, with seven staff members in 1958, developed all the engineerings and construction requirements pertaining to Laboratory tests, consolidated and transmitted these requirements to contracting firms, and coordinated all construction work in the field. A two-person headquarters office was responsible for directing the work of the three sections. L-6 engaged in two major nuclear tests and two minor Plowshare field projects in 1959. Six engineers were stationed at PPG, assisting in the final phases of construction and support for Hardtack I. L-6 formulated and transmitted to the contracting and engineering firms all the engineering and construction requirements for the Laboratory's program, and coordinated field construction work. After Hardtack I was completed in July 1959, one person from L-6 remained through August to complete transportation and removal of equipment. One engineer was detached from operational support to take up residence at the Chariot Camp in northwestern Alaska. L-6 prepared most of the Plowshare projects, including Plumbbob balloon shot and Project 58-A safety test at NTS.

Chemistry Division- Livermore

At Livermore, the Chemistry Division devoted approximately 50 percent of its activity to scientific support of weapon projects. More than half of the remaining effort supported Pluto, Sherwood, and Plowshare programs. The D ivision was comprised of three major groups. In 1958, Radiochemistry consisted of 40 people; Chemical Engineering had 60 members; and General Chemistry had approximately 70 persons. In 1967, the department consisted of four groups totalling 370 members: General Chemistry (including work on explosives), Process and Materials Development (including study of irradiation effects on materials); Radiochemistry (supporting LRL's Weapons, Plowshare, Reactor, and Biomedical Programs); and Refractory Materials.

Radiochemists diagnosed nuclear detonations by conducting analyses of radioactive debris gathered in the bomb clouds. Mounted with filters, test aircraft gathered debris an hour or two after the detonation. The filters were flown back to the Livermore Laboratory where the radioactive particles were placed in a homogeneous solution, followed by the long process of analyzing the fission products and tracers. Radiochemistry undertook a program to devise a method of sampling nuclear clouds with rocket aircraft sampling, and eliminated exposure of the air crew to radiation.

With the resumption of nuclear testing in 1962, the Radiochemistry section made diagnostic measurements of all LRL tests and devised methods for sampling bomb debris from both underground and atmospheric tests. One of the most ambitious experiments was the measurement of neutron-capture sections of uranium, thorium, hafnium, and gold emitted in the Plowshare Gnome event near Carlsbad, New Mexico in December 1961. In 1969, a chemical processing facility was constructed for decontamination of radioactive gases released from underground nuclear explosions in Mississippi and for separation of heavy elements produced in underground nuclear explosions at the NTS.

General Chemistry investigated the chemical reactions of explosives. Process and Materials Development studied iradiation effects on rock and metal deformation and polymers. A major activity of the Chemical Engineering group was the development of chemical procedures to contain radioactive materials, including the operation of a chemical processing facility to decontaminate radioactive gases from underground explosions. A second important activity at Livermore was the separation and identification of heavy elements produced in underground nulcear explosions a the NTS.

Within Process and Materials, the Metallurgy Section developed materials from uranium, thorium, beryllium, and their alloys for the Weapons Program, and tungsten and rhenium for the Reactor Programs. Plastics Section developed plastics for weapons applications.

Radiochemistry Division measured all nuclear tests conducted by LRL. Under the Plowshare Program, the division investigated the production of transcurium elements from nulcear explosions. Other radiochemists worked on high-altitude diagnostic systems as part of atmospheric testing, including participation in PPG field test preparations, obtaining radioactive debris and gas samples from the atmosphere, using an airborne radar system to detect and delineate nuclear clouds.

Earth Sciences

Earth Science Group made extensive measurements of the underground experiments of Hardtack II, mapping Rainier, Blanca, Logan, and Neptune events to determine radiation and temperature distribution, thermal energy, and various geological phenomena. From the data developed at Gnome, Earth Science devised a temperature and radiation system. [See LRL-Nevada.]

Photographic Group

The Technical Film Group provided photographic services, using in-plant camera, lighting equipment, sound-recording systems, time lapse and time-motion photography. The Photography Group also was assigned to Plowboy, and produced two Plowshare films ("Industrial Applications of Nuclear Explosions-- Mining"; "Creating Experiemnts with Chemical Explosives").

The Photography Group provided documentary and scientific film processes and safety movie coverage for all LRL experiments at NTS and high-speed photographic studies of tests, including miniature blast models. The group also used a radiocontrolled system of remote photography of nuclear events.