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BACKGROUND INFORMATION

LOS ALAMOS SCIENTIFIC LABORATORY

Operated by the University of California

for the U. S. Atomic Energy Commission

INTRODUCTION

Founded in wartime (1943), the Los Alamos Scientific Laboratory began with a single assignment: to create the world's first nuclear fission bombs. Success in that task was followed by equal success in developing the first thermonuclear weapons.

Since those early days, the Laboratory has broadened its interests. While maintaining its position as the nation's foremost development center for fission and fusion weapons, LASL now devotes a large part of its total effort to exploring peaceful uses of nuclear energy. Some of the Laboratory's equipment and diversified activites are described here.

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Project Rover --- The energy of nuclear fission appears to offer a very attractive means of propelling long-range rockets. Project Rover is a Los Alamos program, administered by the AEC and with support from NASA, aimed at investigating nuclear rocket propulsion. Test reactors designed and constructed at Los Alamos are tested at the Nevada Test Site near Mercury, Nevada, under the supervision of LASL personnel.

Much of the work is on solid-fueled heat-exchanger reactors using uranium-235 as fuel. Propellant gas is forced through channels in the core and absorbs heat generated in the uranium. The propellant then expands through a nozzle to exert thrust. The first such device to undergo tests was Kiwi-A, which was successfully ground tested in mid-1959. Kiwi-A was a first step toward demonstrating feasibility. It since has been followed by two more successful tests in 1960 and tests will continue through late 1961 and 1962, when liquid hydrogen will be employed.

Heat-exchanger reactors for rocket propulsion differ in important ways from reactors designed to propel ships or to produce electric power or process heat. They must be relatively light in weight, operating at high power densities and high temperatures. They must be capable of being brought from zero power to full power in an extremely short time. These requirements produce formidable problems in core design, in materials development, and in control engineering.

Other devices of possible interest in rocket propulsion are also under study. The plasma thermocouple, which in 1959 achieved direct conversion of nuclear reactor heat to electrical power, is a Los Alamos invention. A modest amount of work has been done on solar sail concepts and studies in other exotic propulsion methods.

Project Rover engages the talents of physical chemists, chemical engineers, mechanical engineers, physicists, metallurgists, inorganic chemists, radio-chemists, electrical engineers, engineering physicists, mathematicians, and others.

Project Sherwood --- Los Alamos is one of four major locations where work is done on Project Sherwood, the AEC's program of research in the control of thermonuclear reactions. If the Sherwood project succeeds, the deuterium in the oceans of the planet will serve as a virtually inexhaustible source of energy, replacing the dwindling supply of fossil fuels and supplementing fissionable and fertile material.

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Controlled thermonuclear reactions (reactions like those that power the stars and the hydrogen bomb) have been achieved only on a laboratory scale, at a large net cost in energy. To produce such a reaction without having to put in more energy than comes out, it is necessary to devise suitable means of confining and heating an ionized gas--probably deuterium. The problem is difficult because of the high temperatures required for thermonuclear fusion. Temperatures in millions of degrees centigrade (hotter than the surface of the sun) have already been achieved, but greater heat is desirable. At temperatures high enough for practical operation of a thermonuclear reactor, no substance could exist in solid form. This means that the confinement of the deuterium plasma must be by non-material walls such as those produced in effect by magnetic or electric fields.

Various approaches to the problem are yielding encouraging results at Los Alamos, which has become a center for advanced research in plasma physics.

Research Reactors --- Two research reactors, designed and built at Los Alamos, are in operation at one of the Laboratory sites. One is the well-known "Water Boiler," which went critical in 1944. It was the world's first homogeneous reactor and the first in which enriched uranium was used. The core is a stainless steel sphere, one foot in diameter, filled with an enriched uranium solution. The Water Boiler is still an important research tool.

The Omega West Reactor (OWR) is of the heterogeneous type. Fuel elements are arranged in a matrix near the bottom of a stainless steel tank about 24 feet tall. Omega West is capable of operation at a power level of more than five megawatts. It provides both fast and slow neutrons for use in research.

Experimental Power Reactors --- One of the missions of the Laboratory is the exploration and evaluation of fuel systems suitable for advanced concepts in power reactor design. Interest is particularly high in developing systems in which the cost of fuel refabrication is minimized through the use of mobile fuels and high utilization of natural resources is obtained by plutonium-fueled breeders. Reactors using highly corrosive uranium phosphate solution have been built and successfully operated. Some of the experimental systems under study are designed to investigate possibilities of extremely simple and compact power sources.

Critical Assemblies --- Critical assembly machines operated by remote control and observed by closed-circuit television enable the Laboratory to assemble critical masses of fissionable materials in safety. One of these devices is Godiva II, a bare, highly enriched uranium metal assembly. Godiva provides a high flux of near-fission-spectrum neutrons. Like Godiva I, which it replaced in 1957, Godiva II can be operated at prompt critical to give intense but self-limiting bursts of fission neutrons and gamma rays.

A typical use of Godiva II has been in a program involving measurements of energy and time dependence of delayed gammas from fission. The measuring device is a crystal of sodium iodide, four inches in diameter, inside a heavily-shielded tank. To reduce the time between irradiation and measurement, material irradiated by Godiva is pneumatically transferred from the critical assembly to a position in the counting geometry.

Jezebel, an unreflected plutonium metal assembly, has been used to study the detailed behavior of plutonium in such a reactor.

Hydro, a water-cooled enriched uranium assembly, produces about one kilowatt of power in supplying large numbers of neutrons for the exponential column which was set up in 1957. The column is outdoors and slightly elevated, to avoid the effect of neutrons reflected from walls or ground.

Among many other machines in the critical assemblies laboratory is the Honeycomb. This device, which serves a purpose analogous to that of the "bread-board" in circuitry, makes it possible to investigate experimental reactor systems without building elaborate mockups.

A second Jezebel, using uranium-233 instead of plutonium, has recently been put into operation.

The Cavity Reactor Experiment was recently set up to simulate a gas phase reactor and it is useful for research where a large space with a constant neutron flux is needed.

Particle Accelerators --- The particle accelerators in use at Los Alamos include one of the world's highest voltage electrostatic accelerators, two smaller 2.5 Mv electrostatic accelerators, a variable energy cyclotron, Cockcroft-Walton accelerators, and various betatrons. A 350-Kolovolt pulsed neutron generator will soon be in operation.

The electrostatic machines can provide beams of any of the hydrogen or helium isotopes, and the cyclotron routinely is used to produce hydrogen, deuterium, He^3, or He^4 beams. Thus, experiments involving the acceleration of tritium and He^3 are possible.

Rather unusually good facilities are available at the accelerators for experiments not only with the charged particle beams themselves, but also with neutrons and gamma rays. Collaboration in experiments using the accelerators by nuclear physicists, radiochemists, and cryogenists enables a wealth of other techniques and unique equipment to be used.

Mathematics and Computers --- The Laboratory is one of the nation's most advanced centers for electronic computing. The famous MANIAC (Mathematical Analyzer, Numerical Integrator and Calculator) was designed and built here. Its place has now been taken by the even faster and more versatile MANIAC II. There also are three IBM 704 computers and a host of smaller electro-mechanical calculating machines. One of the 704 systems will be succeeded by a powerful solid-state IBM 7090 computer, soon to be put into operation. The 704's are complemented with off-line printing and card-reading equipment as well as graph-plotting machines. Two of the 704's have recently been equipped with core memory capacities of 32,768 words each.

The installation of the IBM STRETCH system will expand greatly the computing capability of LASL in a wide range of projects. The logical design of STRETCH, the most powerful computer in the world today, was worked out by IBM in consultation with a LASL committee.

Programming techniques in general and automatic programming in particular are being intensively investigated, developed, and improved at Los Alamos.

Health Research --- The Health Division carries the basic responsibility for the health and safety of all members of the Laboratory staff. Beyond this, the Health Division has long been doing research on world-wide aspects of health as related to atomic energy. The Laboratory conducts extensive health research in radiobiology, biophysics, organic chemistry, and industrial hygiene. Designing radiation detection devices, developing decontamination techniques, studying effects of radiation on tissue, and performing radiation safety work in general are important parts of this phase of the Laboratory's program.

The Laboratory is also concerned with various aspects of space biology--problems of maintaining the human organism at peak health and efficiency in environmental conditions existing beyond the earth's atmosphere and beyond the influence of earth's gravity. This involves not only predicting what conditions will be found in outer space but also what responses the human body will make to such conditions, and what protective mechanisms will best assure top performance by the space explorers of the future.

High Speed Cameras --- In connection with experiments involving explosions and other short-term events, Los Alamos scientists and engineers have found need for many photographic devices heretofore non-existent. This need has led to numerous inventions and to a general sophistication of previously available photographic techniques.

Personnel of the Laboratory have developed high-speed cameras capable of taking photographs at rates faster than 15,000,000 frames per second.

High Explosives Research --- A large group of Laboratory scientists and engineers are engaged in research and development activities concerned with high explosives. Much of this effort is applied research, devoted to creating new high explosive configurations applicable to new weapons systems and satisfying new behavioral or environmental requirements. Concurrent development effort devises novel methods of fabricating explosives, as well as investigating the behavior of detonating systems, and determining the stability and long-term storage characteristics of explosives. From this work has come an entirely new capability in explosives technology, in which these materials are fabricated with ease, precision, and intricacy heretofore reserved for the common metals.

An essential part of this applied research is investigation of the detonation behavior of explosives, and their interaction with other materials. Utilizing the techniques of explosives optics - the controlled shaping of detonation waves - energy may be concentrated to produce temperatures and pressures not otherwise available short of nuclear explosions. These methods are exploited in studies of the properties and behavior of materials at super-elevated pressures, e.g., equations of state.

In support of these activities there is a broad program of fundamental research embracing theoretical study of the detonation process, investigations of detonation and initiation behavior of explosives, studies of fast reactions in shocks, as well as determination of the chemical properties of explosive materials and synthesis of new compounds in the search for superior new explosives.

Facilities available for these varied programs are novel indeed: The explosives fabrication work has been accompanied by the design of altogether new types of presses, machine tools and the like for making complex, precision pieces of explosives (the Laboratory has consistently been a leader in this respect, and has provided the ordnance industry with a host of new techniques). For testing explosives systems there are high acceleration air gun and launcher facilities, together with vibration testing equipment of unique operating characteristics. The recording of various events in explosives phenomenological investigations uses ultra-high fast electronic methods, as well as very high speed streak and framing cameras. Among facilities used in fundamental hydrodynamic research are shock tubes, electron and X-ray densitometers.

Electronics --- Electronics specialists are connected with various programs and research teams in the Laboratory. In addition, the electronics group in the Physics division devotes its full time to instrumentation and other electronic fields. Special needs in other groups and divisions of the Laboratory from the basis for some of the work assignments in the electronics group. The group has done advanced development work on image converters and multiple channel analyzers.

Chemistry and Metallurgy --- Chemical and metallurgical problems related to fission and fusion devices present a challenge of first magnitude to the scientist and engineer. Problems of this nature, both fundamental and applied, are intensively investigated at Los Alamos. In many cases, properties of materials have to be studied over a temperature range from that obtainable with electrical heating equipment down to that of liquid helium. The Laboratory's cryogenic facility permits investigation in the latter range and contributes to a number of basic studies at low temperature. Extensive physical and chemical analytical services are performed.

Research in chemistry is largely in the fields of physical and inorganic chemistry and chemical physics. Special attention is given to the chemistry of uranium, plutonium, deuterium, tritium, and their compounds useful in nuclear energy systems.

The Laboratory does extensive work in radiochemistry, radiation chemistry, reaction kinetics, solution and combustion calorimetry, aqueous and non-aqueous solution chemistry, infra-red, visible, and ultra-violet spectroscopy, and the development of new analytical chemistry methods.

Small but intense gamma radiation sources of lanthanum-140 are prepared. These "RaLa" sources range up to 10,000 curies, equivalent to several times the known amount of extracted radium in the world.

Machining and Fabrication --- The Laboratory has unusual facilities for shop work, including the machining of high explosives and of heavy metals such as uranium and plutonium. A glass-blowing shop operates full-time to create special glassware for instrumentation and a variety of other uses. One of the Laboratory's precision presses is capable of exerting a pressure of 5,000 tons.

Testing --- Under the general heading of "testing" come a considerable variety of LASL operations. The Laboratory operates a large facility for testing nuclear rocket propulsion devices at the AEC's Nevada Test Site. The testing of non-nuclear explosives of interest in nuclear weapons is a continuing program, as is the testing of experimental power reactors. A group devoted to non-destructive testing has available all modern techniques and conducts an active program of creating new test methods dictated by novel test requirements; an important amount of their effort is now concentrated in the rapidly-expanding field of electromagnetic non-destructive testing.

Opportunities for Advanced Training --- The Los Alamos Graduate Center of the University of New Mexico offers valuable opportunities for graduate study. Requirements for the master's degree in the physical sciences, engineering, and mathematics may be met in full through evening classes at Los Alamos. For the B. S. and Ph. D. degrees, some residence on the Albuquerque campus is required, but credit is given for course work taken at Los Alamos.

In support of the graduate program a number of undergraduate courses are also offered at Los Alamos, as well as some specialized non-credit technical courses.

In addition to the opportunities just described, the following programs are in force:

1. Advanced Study Program -- providing a year of graduate study at some recognized university for selected Staff Members.

2. Graduate Thesis Program -- in which selected candidates for advanced degrees from universities throughout the nation are hired for a limited period of time to perform research for a thesis.

3. Professional Research and Teaching Leave -- wherein a few senior Staff Members are partially subsidized on leave while undertaking research or teaching at some university at home or abroad.

4. Summer Graduate Student Program -- in which, each summer, about 100 graduate students from some fifty universities are brought to Los Alamos to participate in the work of the Laboratory.

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5. Summer Consultant Program -- wherein some 30 to 50 eminent leaders in various fields of science are brought to Los Alamos to consult and lecture.

Technical Libraries --- Among the Laboratory's facilities are the main library and its twenty-nine branches. They constitute one of the largest technical libraries between the Mississippi and the Pacific coast.

The main library has more than 75,000 volumes of books and bound periodicals, covering mathematics, chemistry, physics, metallurgy, electronics, and other fields with which the Laboratory is concerned. The technical report library now has about 250,000 reports.

The branch libraries, some of which are small and highly specialized, are located in various Laboratory buildings. Largest of the branches is the 20,000-volume medical library. A plastics branch and a ceramics branch are among the others.

The Los Alamos libraries maintain subscriptions to about 1,000 technical journals in many languages, and to a number of translated journals. Any available publication which is not at Los Alamos can be speedily obtained on interlibrary loan.

Laboratory Administration and Organization --- The Laboratory, from its beginning, has been managed and operated by the University of California, as a contractor first for the Army's Manhattan District and more recently for the U. S. Atomic Energy Commission. All Laboratory personnel are employees of the University of California. They are in no way subject to federal Civil Service employment conditions. The Laboratory's professional scientists and engineers number about 1,200 or one-third of the total Laboratory staff. They are divided among a number of technical divisions, which in turn are divided into groups varying widely in size and function. Project teams are drawn from the various divisions for special problems such as some of the field tests.

The entire organization is flexible and informal. Little attention is paid to rank or title. Every effort is made to maintain an academic atmosphere conducive to research. Regimentation, red tape, and protocol are systematically held to a minimum. Administrative services are largely centralized to relieve the scientific staff of paper work.

While most people work a normal 8 hour day, 5 days a week, staff members have free access to their laboratories and offices at any hour of the day or night, at their own discretion. It is not uncommon for groups to run experiments around the clock. There are no time clocks for scientists and engineers.

There are no salary grades or classifications for members of the Laboratory's professional staff. Advancement and salary increases are based entirely on individual merit.

Since all members of the Laboratory staff carry the AEC's top security clearance, there is no barrier to free communication within the Laboratory and with scientists in other institutions concerned with nuclear energy. There are many technical discussions open to all staff members. The Laboratory encourages publication of technical papers and provides expert editorial assistance in their preparation.