UNITED STATES ATOMIC ENERGY COMMISSION

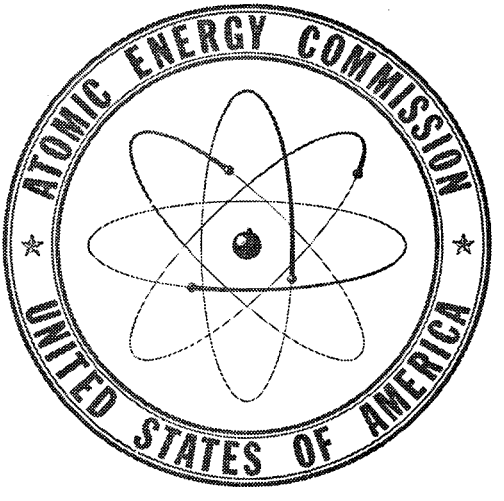
MAJOR ACTIVITIES

IN THE

ATOMIC ENERGY PROGRAMS

January–December 1962

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THE ATOMIC ENERGY PROGRAM—1962

The year 1962 was one in which the nation's nuclear energy program continued to move forward on an ever-broadening front. As the 20th anniversary of man's first creation of a controlled and sustained atomic fission reaction was observed, science, industry, and the Government were working together to consolidate the gains of the past into a future program that would continue to bring forth a clearer realization and effective utilization of the potential economics and benefits to be derived from the atom and its hidden energy.



Commissioners and The President. During the year, two new members were sworn in as Atomic Energy Commissioners to fill the vacancies created when John S. Graham resigned and the appointment of Loren K. Olson expired. Named as their replacements were James T. Ramey, formerly Executive Director of the House-Senate Joint Committee on Atomic Energy, and John G. Palfrey, formerly Dean of Columbia University Undergraduate College. Photo shows the five members of the Commission and President Kennedy on the White House steps after the December 3 presentation of the AEC's Enrico Fermi Award to Dr. Edward Teller. *Left to right* are Commissioner Leland Haworth, Commissioner Ramey, Commissioner Robert E. Wilson, President Kennedy, Commission Chairman Glenn T. Seaborg, and Commissioner Palfrey.

During the year, five new experimental or developmental atomic power plants added nearly 300,000 kilowatts of electricity to the nation's total as other new and larger plants were proposed by industry, and the Commission redefined its role for "bridging the gap" between the infancy and maturity of nuclear power; the safe and efficient use of nuclear explosives for beneficial, large-scale excavation projects passed the threshold of development; industry demonstrated a capability to perform nearly all of the services necessary for utilization of atomic energy for peaceful purposes; science made noteworthy discoveries regarding the internal composition of the atom and its usefulness to mankind; some States assumed greater roles in promoting and regulating the beneficial uses of atomic energy—1962 was a year of advancement. Although the number of "firsts" was not as impressive as in 1961, they did provide a solid foundation for the future.

In this Annual Report to Congress of the Atomic Energy Commission for 1962[1] are summarized the major activities of Government and the nuclear industry during the past year. Some of the more significant achievements made under Commission-sponsored basic research in the life and physical science fields and the exploratory development area for reactors and management of radioactive wastes are discussed in a supplementary report, "Fundamental Nuclear Energy Research—1962".[2]

In summary form, below, are some of the more noteworthy events and activities of 1962, listed not in order of importance but rather in sequence of mention in this report:

Part One—Commission Actions

Actions in Support of Industry and Science

- The commission has continued to study the desirability of permitting private ownership of special nuclear materials and of proposing specific legislation to accomplish this objective.
- Prices for enriched uranium again were lowered as were prices for a number of important radioisotopes; isotopes of new "heavy elements" were made available for scientific uses.
- Approval was given for use of tritium in self-illuminating automobile locks and safety signs in airplanes.

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[1] This Annual Report is available to the public under an alternate title, "Major Activities in the Atomic Energy Programs—January–December 1962", from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

- The criteria used as guides by the Commission in evaluating proposed nuclear reactor sites were made public.
- A Commission study has shown that private industry has developed a capability to provide most of the materials and services needed in the first cycle of peaceful commercial utilization of nuclear energy. Important exceptions are uranium enrichment, chemical reprocessing of spent fuel, and storage of high-level liquid wastes. Of these, it is anticipated that private capabilities in spent fuel reprocessing and high-level liquid waste management will soon be initiated.
- With the help of industry, the AEC has made the first comprehensive categorization of the various segments of the nuclear industry.



20th Anniversary Highlight. As part of the nation's observance of the 20th anniversary of man's creation of a sustained and controlled atomic chain reaction, President Kennedy was shown a plastic model of the Enrico Fermi "pile" reactor in which the atom's energy was first harnessed on December 2, 1942. Within the reactor is embedded a one-inch cube of uranium that was part of the original fuel. The model is now on display in the Hall of Nuclear Energy in the new Smithsonian Museum Building in Washington, D.C. Some 35 members of the original "Fermi team" of 50 scientists, engineers, and technicians were in the group visiting the White House for the ceremony. In the front row, *left to right*, of the photo are: Dr. Leona Woods Marshall and Dr. Alvin C. Graves of the "Fermi team"; AEC Chairman Glenn T. Seaborg; President Kennedy; and Robert G. Nobles, Robert E. Johnson, and Dr. Volney C. Wilson who also worked with the Italian-born scientist on the world's first atomic reactor at the University of Chicago. During the ceremony, Italian Ambassador Sergio Fenoaltea (barely visible behind microphones) paid tribute to the memory of Fermi.

- A Bureau of Census survey showed that the value of domestic atomic product shipments for 1961 declined slightly: to $270 million from the $287 million level for 1960.
- The Bureau of Census survey also showed that the Middle Atlantic geographic area led in the value of atomic product shipments in 1961, followed by the Pacific Coast and New England areas.

General Actions and Activities

- Oak Ridge National Laboratory was authorized to take part in the U.S. Department of Interior's basic research program on saline water conversion.
- The Commission revised its personnel security regulations to permit, except in certain instances, AEC employees or applicants for AEC employment to confront and cross-examine informants in security clearance proceedings. The Commission is the first Federal agency to grant this right.

Community Support

- The Commission approved a policy to cooperate with the efforts of the communities of Oak Ridge, Tenn., and Richland, Wash., to become less dependent for their economic well-being on the consummation of AEC-financed activities. As a part of this cooperative effort, the Commission changed the name of its Hanford Operations Office to that of Richland Operations Office, effective January 1, 1963.
- The termination of AEC ownership and management of the community of Los Alamos, N. Mex., was authorized. At the same time, the Commission began making studies to determine the need for a community in Nevada to enable the recruitment and retention of scientific and professional personnel for the Rover program located at the new Nuclear Rocket Development Station in Nevada.

Patent Matters

- An additional 247 Commission-owned U.S. patents were made available for licensed use; the portfolio of such patents now numbers 2,974.

Scientific Awards

- Dr. Edward Teller, who was instrumental in the development of the thermonuclear weapons among other scientific achievements, was named the 1962 winner of the AEC's Enrico Fermi award, and five scientists shared the Commission's E. O. Lawrence Award.



Fermi Award. Dr. Edward Teller, internationally known nuclear scientist, received the AEC's $50,000 Enrico Fermi Award for 1962 in a White House ceremony on December 3. In addition to the check, which was presented by President Kennedy to the Hungarian-born scientist who is now Associate Director of the AEC's Lawrence Radiation Laboratory, Dr. Teller received a gold medal and a citation. Photo shows Commission Chairman Glenn T. Seaborg and Dr. Teller holding the citation as Mrs. Teller and the President look on.

Presidential Visit

• President Kennedy made a trip West in early December which included visits to two AEC weapons laboratories in New Mexico and the ROVER test facilities in Nevada. This was the first presidential visit to these facilities. Previously, during March, the President had visited AEC facilities in California. (Photos and summary are included in the Space Propulsion section of Part Two.)

Part Two—Nuclear Power Programs

Nuclear Power Development Study

• At the request of the President, the Commission conducted a comprehensive study of the nation's long-range power requirements and recommended steps to be taken to meet them. The report on the study

was delivered to the President on November 20, and recommended that the Government provide economic incentives to private and public utilities to bring the already-developed water-cooled types of reactors into more widespread use; that advanced type converter reactors be developed; and that research and development work on breeder reactors be expanded.

Civilian Power Reactors Program

- Five new nuclear power plants reached the operational or near-operational stage during the year. On April 12, the Saxton Nuclear Experimental Reactor reached criticality; Consolidated Edison Company's nuclear power station at Indian Point, N.Y., attained initial criticality on August 2; the reactor of the Hallam Nuclear Power Facility achieved wet criticality on August 25; the Big Rock Point Nuclear plant of Consumers Power Co. near Charlevoix, Mich., achieved initial criticality on September 27; and the Elk River Reactor in Minnesota attained criticality on November 19. When fully operational, the 1,060,200 kilowatts of thermal energy produced by these reactors will be equivalent to about 293,050 nuclear electrical kilowatts.[3]

- At year's end, seven nuclear power plants that had been scheduled for operation by the end of 1962, had not yet achieved criticality—the Carolinas-Virginia Nuclear Power Associates plant at Parr, S.C.; the Pacific Gas and Electric Co., Humboldt Bay plant at Eureka, Calif.; the Experimental Gas Cooled Reactor at Oak Ridge National Laboratory, Tenn.; the Power Reactor Development Co. plant at Lagoona Beach, Mich.; the City of Piqua, Ohio, plant; the BONUS plant in Puerto Rico; and the Pathfinder plant at Sioux Falls, S. Dak.

- The Shippingport Atomic Power Station completed 5 years of power operation on December 23, during which it has had three seed refuelings. The reactor is presently operating with its fourth seed and its original natural uranium oxide blanket. This blanket has so far operated for an estimated 20,900 equivalent full power hours and has reached an average burnup of approximately 6,800 megawatt-days per ton of uranium oxide. The blanket fuel elements were designed for a life expectancy of 8,000 full power hours, an objective that was surpassed on September 6, 1960.

- The Yankee Atomic Electric Co. reactor at Rowe, Mass., was shut down for the removal of its first core during May and Core II was installed in the reactor in July. The reactor resumed operation

[3] Details of the various reactors are described under the pertinent sections of Part Two of this report and in Appendix 7.

September 19. The new core is expected to result in an increase in the gross electrical capacity of the Yankee plant from approximately 150,000 to approximately 165,000 electrical kilowatts. To date, Yankee has generated more than one and one-half billion kilowatt-hours of electricity.

• The AEC announced on February 1 its decision not to go forward at this time with construction of the 50,000 electrical kilowatt prototype organic power reactor.

• On February 13, the Dresden Nuclear Power Station became the third reactor in the United States to produce one billion gross kilowatt-hours of electricity, having been preceded on December 26, 1961, by the Shippingport Atomic Power Station and on January 12, 1962, by the Yankee Nuclear Power Station. By year's end, Dresden had produced over two billion gross kilowatt-hours of electricity. On September 5, the Commission approved an 11 percent increase in the power level of the Dresden reactor which will result in the generation of 200,000 rather than 180,000 kilowatts of electricity.

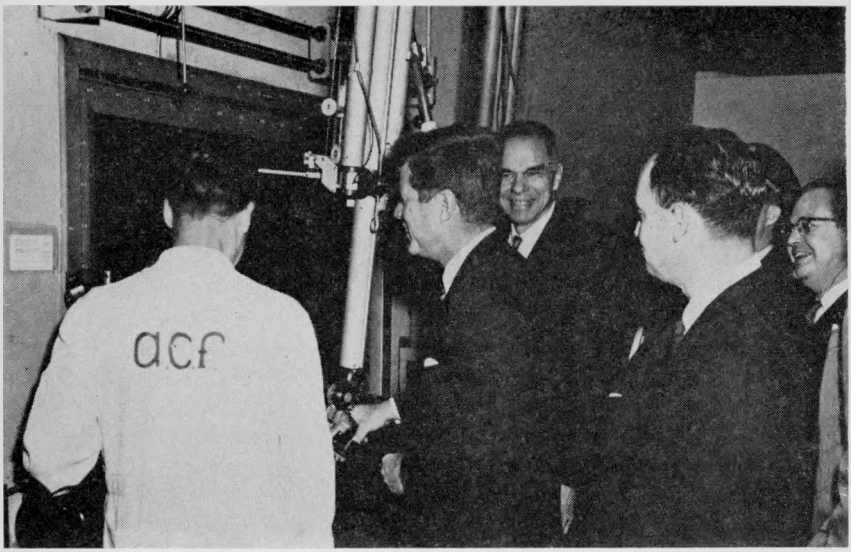
• The AEC executed contracts with Allis-Chalmers Manufacturing Co. and the Dairyland Power Cooperative for the construction of a 50,000 electrical kilowatt boiling water reactor near Genoa, Wis., on June 6. Construction of the plant is scheduled to be essentially complete by May 1965.

• The New York Operations Office was authorized, late in June, to enter into a contract with Westinghouse Electric Corp. for the conduct of a nine-month study program to determine the technical feasibility and economic potential of a one million kilowatt central station power plant of the pressurized water type.

• On August 23, the AEC invited proposals from industry for the design, construction, and operation of large-scale nuclear power plants powered by proven-type reactors capable of producing at least 400,000 gross kilowatts of electricity. Under the terms of this invitation the AEC would, for the first time, make design assistance available to private organizations. Proposals were to be submitted during January 1963.

Maritime Reactors

• On May 1, the Maritime Administration, Department of Commerce, accepted the world's first nuclear-powered cargo-passenger ship, the NS *Savannah*, from her builder. The vessel visited Savannah, Ga., and Norfolk, Va., in August and made her first trip to Pacific ports beginning in October. More than 175,000 visitors toured the ship when she visited her first three ports of call—Savannah, Ga., Norfolk, Va., and Seattle, Wash.



Presidential Operator. President Kennedy tried his hand at operating the mechanical hands of a remote "master-slave" manipulating device during his December 8 visit to the Commission's Nevada Test Site, which included a tour of the new AEC–NASA Nuclear Rocket Development Station. In photo, an ACF Industries, Inc., technician (*left*) instructs the President in the use of the "master-slave" manipulator as AEC Chairman Glenn T. Seaborg looks on. In *foreground* is Harold B. Finger, Manager of the AEC-NASA Space Nuclear Propulsion Office, and at *right* is U.S. Senator Alan Bible of Nevada. ACF Industries does maintenance, assembly, and disassembly work on nuclear reactors being tested under Project ROVER at the Nevada facility.

Project ROVER

- The industrial team of Aerojet-General Corp. and Westinghouse Electric Co. was awarded a follow-on 5-year contract in connection with the Nuclear Engine for Rocket Vehicle Application (NERVA) project during January 1962. Their work will be a continuation of the technology developed under the KIWI reactors program.
- In February, an agreement was entered into between the AEC and NASA for the establishment and operation of a Nuclear Rocket Development Station (NRDS) at the Nevada Test Site; and the Nevada extension of the Space Nuclear Propulsion Office (SNPO–N) became operational at Las Vegas in early October. The Office has financial and contract responsibilities for the construction of facilities at the NRDS, the national site for static ground testing of nuclear-powered rockets.
- Lockheed Missiles and Space Co., Palo Alto, Calif., was awarded a contract during June for the development of a Reactor-in-Flight-Test (RIFT) stage to be used for the flight test of the NERVA.

• Early in September, successful start-up of a reactor using liquid hydrogen as a feed was demonstrated for the first time during a ground test of the KIWI–B1B.

Project PLUTO

• The Department of Defense requested that the AEC continue with the PLUTO program beyond the Tory IIC phase and into a propulsion system ground test phase in a January letter. In a November letter, however, the Department of Defense excluded the propulsion system ground test program from future work, but provided strong support for continuation of the Tory IIC program and for studies applicable to sea-based missiles.

• Construction began on the Tory IIC facility early in the year; completion is scheduled for February 1963.

SNAP Program

• A 10-watt, strontium 90 fueled generator, 19 inches in diameter and 21 inches high, was installed in the Antarctic and, on February 8, began powering a Navy automatic, unmanned weather station located in the ice near McMurdo Sound.

• June 29 marked the first anniversary of the world's first use of nuclear power in space. The 4.5-pound, grapefruit-sized, 2.7-watt, plutonium 238 fueled SNAP (Systems for Nuclear Auxiliary Power) thermoelectric unit which was shot aloft to power two of the transmitters in the Navy's TRANSIT–4A experimental navigational satellite had, at the end of the first year of operation, traveled 142 million miles, orbited the earth 5,000 times, and produced 23,650 watt-hours of electricity.

• On April 13, the Commission requested Pratt & Whitney to undertake the development of an advanced nuclear reactor to meet space power demands in the 300 to 1,000 electrical kilowatt range. The first phase of the SNAP–50 program includes project planning, preliminary design of the lithium-cooled reactor and primary system, uranium carbide fuel development, critical experiments and component development.

• The Commission authorized a short-term study with the Martin-Marietta Corp., Baltimore, Md., to design a 500-watt thermionic generator which can be fueled with radioisotopes such as cerium 144, plutonium 238, or polonium 210, and might have application in communications satellites or in other space systems which need relatively large amounts of power.

Army Reactors Program

- Three Army reactors—the SM–1A in Alaska, the PM–1 in Wyoming, and the PM–3A in the Antarctic—began operation during the February–April period.
- On September 20, 1962, the 300–500 ekw ML–1 plant became the first mobile nuclear reactor to produce electricity in a successful power ascension run of several hours at the National Reactor Testing Station in Idaho. The world's first direct- and closed-cycle gas-cooled nuclear power system is composed of six major components, each mounted on a skid, so that it can be transported by standard cargo planes or standard low-bed Army trailers.
- In October, a small flash fire broke out in the PM–3A reactor—the first land-based power reactor to operate in the Antarctic—and caused minor damage. No personnel were injured and no radiation was released. Although the plant was restored to an operable state within a week, other technical difficulties caused the plant to be shut down by year's end for contractor correction of plant deficiencies.
- On June 27, the AEC authorized negotiation of a contract with the General Motors Corp., as prime contractor, and United Nuclear Corp., as nuclear project associate, for the design, development, fabrication, assembly, and test operation of a Military Compact Reactor (MCR)—a prototype mobile nuclear power plant capable of operation as a piece of military field equipment.
- A final report on the investigation into the reasons for the January 3, 1961, SL–1 reactor accident which caused three deaths, said the accident could only have been caused by ". . . manual withdrawal by one or more of the maintenance crew of the central control rod blade from the SL–1 core considerably beyond the limit specified in the maintenance procedure. . . ."

Naval Reactors Program

- Fourteen additional submarines and one additional destroyer leader were authorized by Congress. This brings the Navy's nuclear fleet to an authorized level of 3 destroyer leaders, 1 aircraft carrier, 1 cruiser, and 75 submarines—35 of which are of the Polaris type that can launch ballistic missiles.
- Six additional submarines were commissioned, bringing the Navy's operating nuclear fleet to a level of 1 aircraft carrier, 1 cruiser, 1 destroyer leader, and 28 submarines—10 of them of the Polaris type.
- The nuclear-powered destroyer leader *Bainbridge* completed initial sea trials on September 2 and was commissioned as a ship of the U.S. Navy on October 6.

• The nuclear powered, guided missile cruiser *Long Beach* operated with the Atlantic Fleet early in 1962 to evaluate her nuclear propulsion plant. During these operations, she visited Europe and traveled a total of 39,029 miles. Following these operations, the *Long Beach* entered the Philadelphia Naval Shipyard where installation of her weapons system is scheduled for completion early in 1963.

• The aircraft carrier *Enterprise* completed her first full year of operations in 1962. These operations included deployment to the Caribbean during the Cuban crisis and operations with the Sixth Fleet in the Mediterranean.

• On August 2, the nuclear submarines *Skate* and *Seadragon* met at the North Pole, having traveled submerged from New London, Conn., and Pearl Harbor, Hawaii, respectively.

• As of December 31, 1962, nuclear-powered Navy ships had traveled approximately 2¼ million miles.

Nuclear Safety Program

• A series of short-period tests in which a SPERT–1 reactor core was intentionally damaged were completed during the year. These tests were part of a series which terminated in an intentional 3.3 millisecond period excursion in which the core was destroyed on November 5.

• A series of tests and experiments was initiated to ascertain the effectiveness and validity of the features designed into the SNAP systems to assure their safety under prelaunch, launch, preorbital, and postorbital conditions.

• The nuclear safety program for both terrestrial and aerospace reactor systems was expanded to include engineering field reliability and safety tests of nuclear components and systems. Responsibility for conducting these tests has been assigned to the Phillips Petroleum Co. (terrestrial) and the Sandia Corp. (aerospace).

Part Three—Production and Weapons Programs

Raw Materials Program

• Uranium concentrate deliveries totaled 28,690 tons of uranium oxide (U_3O_8) during 1962, of which 17,010 tons were from domestic suppliers, 7,410 tons from Canada, and 4,270 tons from overseas.

• The Commission's program of guaranteed prices for ore and individually negotiated mill concentrate prices expired March 31, 1962. It was superseded by the present 1962–66 procurement program, under which the Commission purchases uranium in the form of acceptable concentrates at an established price of $8 per pound of U_3O_8. The

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ore-buying program had been in effect since April 1948, and during this period domestic uranium production increased from less than 100 tons of U_3O_8 per year to in excess of 17,000 tons; ore production expanded from approximately 15,000 tons a year to more than 8 million tons; and ore reserves increased from about 3 million tons to over 80 million tons. Twenty-four privately owned uranium mills were operating in 1962 as compared with two in 1948.

- On November 17, the Commission announced a "stretchout" program for domestic uranium procurement for the 1967–70 period. The new program consists of a deferral to 1967–68 of a portion of the uranium now contracted for delivery to the AEC before 1967 and the purchase, between 1969–70, by the AEC of an additional quantity equal to the amount deferred. This will assure uranium producers of a market until the anticipated requirements of private power reactors are more firmly established.
- The Commission announced in June that it was relaxing production limitations on small domestic mining properties having production allocations of less than 20,000 pounds of U_3O_8 in ore per year. Effective April 1, 1962, uranium mills have been allowed to contract for the purchase of up to 10,000 pounds of U_3O_8 in ore per half year from individual mining properties with allocations of this amount or less subject to an overall ceiling of 1 million pounds U_3O_8 per year.

Production

- Reductions in unit operating costs were achieved in the production complex when refinery operations were consolidated at Weldon Spring, Mo., and the refinery at Fernald, Ohio, was placed on a standby basis. The plant for conversion of uranium to hexafluoride at Portsmouth, Ky., was also placed in standby early in 1962.
- On December 13, a chemical explosion and the ensuing fire caused $2 million damage to the AEC's Paducah, Ky., gaseous diffusion plant. There were no personnel injuries and no radiation hazard.
- Nuclear Fuel Services, Inc., a subsidiary of W. R. Grace & Co., submitted a proposal to construct and operate a spent fuel reprocessing plant; no private capability for this service currently exists.
- The Commission negotiated a tentative agreement with the Washington Public Power Supply Systems (WPPSS) for construction and operation of electricity producing facilities at its Hanford, Wash., plant as permitted, under specified conditions, by recent Congressional authorization. The WPPSS facilities will use heat drawn from the New Production Reactor (NPR) now under construction; the 800,000 electrical kilowatt generating facility will be the largest nuclear-electrical power installation in the world.

Radioactive Wastes Management

• About 69,000 cubic feet of radioactive waste materials were received from licensees for burial at Commission-owned sites; a total of 2,359,000 cubic feet of Commission-generated and licensee material was buried in fiscal year 1962.

• A long-term study of low-level radioactive waste disposal operations at three Pacific Ocean sites by a National Academy of Science-National Research Council Committee has shown that no radioactive hazard has been created, and that under present procedures an additional 40 sites could be established with safety. The Commission, however, does not plan to establish more ocean disposal sites for use of licensees. In fact, ocean disposal has been declining because of economic factors.

Military Application

• The underground nuclear tests at the Nevada Test Site were continued. As of December 31, 1962, a total of 61 weapons test events in Nevada had been announced for the year, including two test detonations conducted at the Nevada Test Site for the British.

• An atmospheric test series was conducted in the Pacific, with operations based on Christmas Island and Johnston Island. A total of 36 nuclear events were announced during the series which was concluded on November 4, 1962.

• Plans proceeded in conjunction with the Department of Defense, for three nuclear detonations in a salt dome in Mississippi and one nuclear detonation in an active seismic area in Nevada, to increase the capabilities of detecting and identifying underground nuclear explosions. The detonations have not yet been authorized.

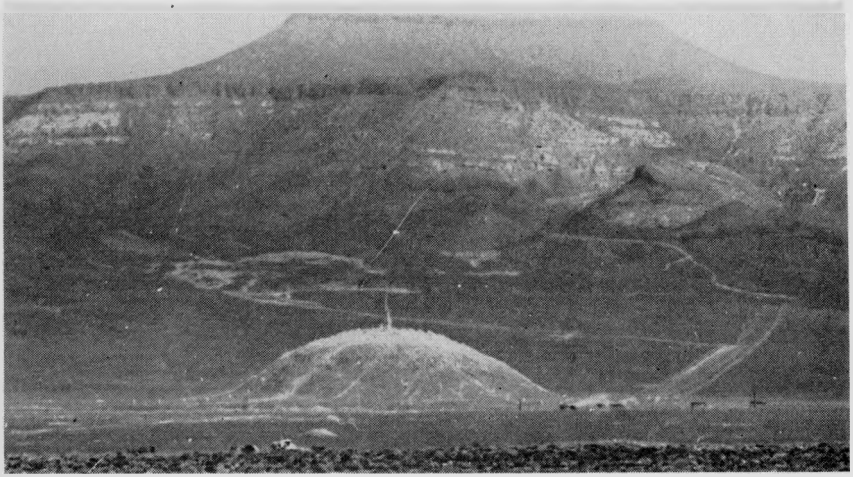
Part Four—Other Major Programs

Plowshare Program

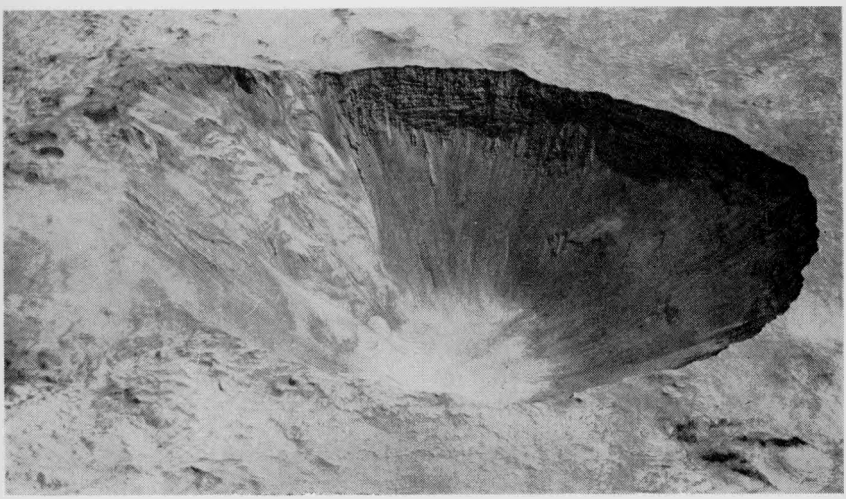
• Within the Plowshare program, in which peaceful uses for nuclear explosives are being developed, a goal of developing nuclear excavation technology within about 5 years was established during 1962 and an experimental program has been planned to reach this goal.

• On July 6, the development necessary for the use of nuclear explosives as an accepted engineering tool took a major step forward when the Commission successfully conducted Project Sedan in the

desert alluvium of the Nevada Test Site. Project Sedan was a 100-kiloton cratering experiment and the first of the experiments planned in the 5-year developmental program referred to above.



Project Sedan. First major nuclear excavation experiment of the Commission's Plowshare program was Project Sedan which was detonated 635 feet under the Nevada Test Site desert on July 6, 1962. The 100 kiloton thermonuclear explosive created a ground surge three seconds after detonation resembling a hemispherical dome 600 to 800 feet in diameter and 290 feet high. Photo *above* shows the earth "bubble" just before it was split open by incandescent gases. Photo was taken from a distance of three miles. Air view, photo *below*, shows the crater, about 1,280 feet across and 320 feet deep, that resulted from the explosion. The lip of the crater varies from 20 to 100 feet in height. About 7.5 million cubic yards of earth and rock were moved in this demonstration of how nuclear explosives can be used in large-scale excavation projects such as digging harbors and canals.



• Site preparation was begun for Project Coach which is being planned for the site of the 1961 Project Gnome experiment. Project Coach, conduct of which has not yet been authorized, would be a scientific experiment to study the feasibility of using a nuclear explosive to produce neutron-rich isotopes of known transplutonium elements and, possibly, of elements heavier than those yet discovered.

Radioisotope Development

• During the past year an Isotopes Development Center was established at Oak Ridge National Laboratory to serve as a focal point for the development of radioisotope technology and for continued evaluation of radioisotope developments on a worldwide basis.

• A Radiation Development Center has been established at Brookhaven National Laboratory to serve as a focal point for Commission research and development activities related to the use of high intensity radiation sources as a processing tool.

• Production and sales of radioisotopes attained record levels in 1962 as 515,637 curies of radioisotopes were distributed and $2.8 million in sales were achieved. Oak Ridge National Laboratory made over 169,000 radioisotope shipments in the 16-year-old radioisotopes distribution program.

• The world's largest single cobalt 60 source, 1,290,000 curies, was produced at Savannah River for use in the Quartermaster Food Irradiation Research Laboratory at Natick, Mass., now completed by the AEC and formally turned over to the Department of the Army.

• The development of a radioisotope method for precisely measuring residual amounts of agricultural insecticides left on foodstuffs is contributing to increased protection of the health of the American public.

• Superior quality materials, made through the irradiation of plastic-impregnated wood, exhibit an increase in hardness, dimensional stability, and improved compressional strength.

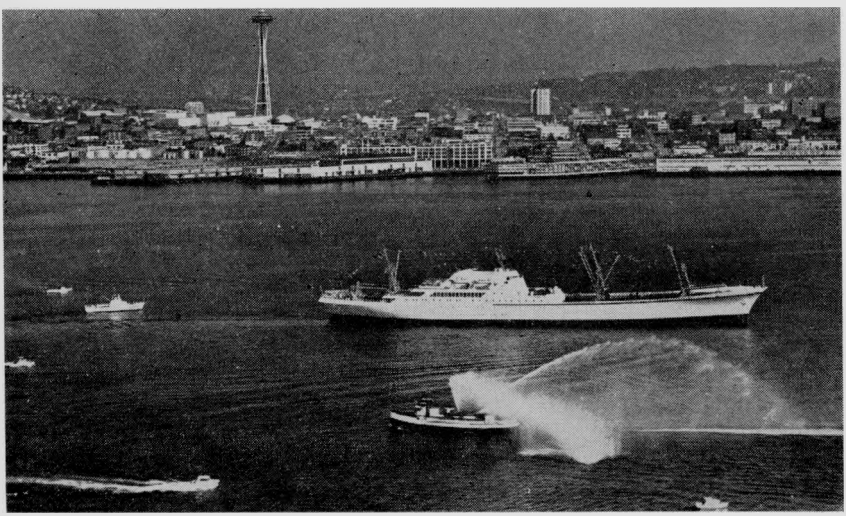
• The application of neutron activation analysis to problems in criminology has opened up an area of unprecedented sensitivity in the law enforcement area.

• In a cooperative program with NASA, devices using radioisotopes are being developed to analyze the composition and density of the atmospheres of the planets.

• Significant achievements have been made in the technology for radiation pasteurization of foods, including the delineation of processing conditions to insure the retention of freshness and nutritional values of certain fish and fruit products.

International Activities

- One new power reactor project was accepted under the U.S.–Euratom power reactor program. A Franco–Belgian firm will build a reactor to be in operation by December 31, 1965.
- India announced the selection of the International General Electric Co. to construct India's first nuclear power station. Arrangements concerning funding and the possible role of the International Atomic Energy Agency (IAEA) in the application of safeguards to the Tarapur facility to assure it is used only for peaceful purposes are still under consideration.
- Transfers abroad of special nuclear materials and heavy water more than doubled those of 1961—bringing to $11 million the value of special nuclear materials which AEC has sold abroad.
- The AEC committed grants of $350,000 each to Argentina, Colombia, and Iran for research reactors to be built in those countries,



NS Savannah at Seattle. Climaxing her maiden two-ocean voyage as the world's first nuclear-powered passenger-cargo vessel, the NS *Savannah* paid a three-week's visit to Seattle, Wash., in October. Approximately 30 passengers made the voyage between Norfolk, Va., and Seattle. In addition, the *Savannah* carried several hundred tons of cargo which had been loaded aboard at Savannah, Ga., and Norfolk for delivery to West Coast ports. The 22,000-ton ship was built as a joint project of the Atomic Energy Commission and the Maritime Administration to demonstrate the feasibility of using nuclear power for merchant ships. The *Savannah* was constructed by the New York Shipbuilding Corp. at its Camden, N.J., yards and is powered by a 69 thermal megawatt pressurized water reactor fabricated by the Babcock and Wilcox Co. at its Lynchburg, Va., facilities. The reactor is fueled with 17,000 pounds of enriched uranium oxide, enough to propel her 300,000 miles over 3½ years. The ship is operated for the Maritime Administration by States Marine Lines of New York.

and paid grants totaling $1,400,000 to Korea, Sweden, Turkey, and Thailand for completed research reactors.

- Brookhaven National Laboratory and the Turkish Cekmece Nuclear Center entered into a cooperative arrangement intended to help assure effective utilization of the U.S. built research reactor located at the Center.
- The first and second IAEA inspections of U.S. reactors were carried out on research reactors at Brookhaven and Argonne National Laboratories, and the power reactor at Piqua, Ohio.
- Greece and West Germany became the first two nations to conclude agreements with the United States under which the NS *Savannah* may visit ports in these countries.
- The United States and Soviet Union signed a new agreement for scientific, technological, educational, and cultural exchanges for 1962–63, including the continuance for 2 years of a reciprocal exchange program in the peaceful uses of atomic energy.
- Contracts approved during 1962 under the U.S.–Euratom Joint Research and Development Program bring the total number of U.S. financed contracts to 34 (cost—$9.57 million) and the number of Euratom supported contracts to over 60 (cost—approximately $15 million).
- The AEC approved equipment grants totaling $491,080 to the IAEA, Mexico, Argentina, Brazil, and India.

International Conferences and Exhibits

- During the year, the Commission furnished financial support to, and/or participation in 25 international topical conferences.
- The Commission's two, large international traveling exhibits were shown in Mexico City, Santiago, Athens, and Bangkok during the year and continued to meet with enthusiastic response. Past exhibitions in Argentina and Brazil have led to incorporation of special nuclear energy courses being incorporated into the curriculum of secondary schools.

Biology and Medicine

- A series of experiments has been carried out at the Nevada Test Site to relate actual radiation dose measurements to the physiological effects noted among the survivors of the Hiroshima and Nagasaki nuclear bombings.
- New biomedical research facilities at Sandia Base, N. Mex., were completed during the year, making it possible to initiate aerosol physics, biochemical, and radiobiology studies into areas of research never before attempted.

• Use of radioactive tracers in medical research led to a number of new findings in the composition and functions of the human body.[4]

Physical Research

• Four new major particle accelerators were completed during the year. The new research "tools" are the 3 billion electron volt Princeton-Pennsylvania Proton Accelerator at Princeton University; the Cambridge Electron Accelerator which will be operated jointly by Harvard University and the Massachusetts Institute of Technology; the 88-inch spiral ridge cyclotron at the Lawrence Radiation Laboratory on the University of California's Berkeley campus; and the Isochronous Cyclotron at Oak Ridge National Laboratory.

• Important discoveries were made regarding the composition of the atom and, for the first time, an inert gas was combined into a chemical compound.[4] Xenon tetrafluoride was produced at Argonne National Laboratory, and gram quantities of xenon difluoride were produced at Oak Ridge National Laboratory as a result of findings made earlier in the year at the University of British Columbia. It was previously believed impossible for any of the noble gases to combine with other elements.

• Ground was broken in July for construction of the 2-mile-long, $114 million linear accelerator being constructed at Stanford University.

• The unexpected discovery and perfection of a variable energy capability has enhanced the usefulness of the Heavy Ion Linear Accelerator (HILAC) at Lawrence Radiation Laboratory (Berkeley).

Classification and Declassification

• During the year, a total of 40,000 documents were reviewed and 38,000 of them were declassified. During the past 16 years, a total of 256,000 documents, useful to science and industry, have been declassified out of the 320,000 documents that were reviewed.

Information Programs

• An estimated 3.7 million persons saw some 104,000 showings of the Commission's 200 popular- and professional-level motion pictures; 31 films were added to the list of films available to the public.

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[4] These, and a number of other basic scientific achievements, are summarized in the supplementary report, "Fundamental Nuclear Energy Research—1962."

Exhibits

- In operation since 1949, the Commission's domestic exhibits program recorded its 50 millionth visitor during 1962. During 1962, an estimated 5,573,000 persons viewed the exhibits.
- In cooperation with the National Science Fair-International, the Commission instituted awards for high school Science Fair entrants with outstanding exhibits related to nuclear science.
- A series of new type exhibits was developed to present specialized atomic energy information and used at large professional meetings.

Education and Training

- The importance of nuclear training as a counterpart to research and development in achieving Commission objectives was formally recognized through the establishment of a specific division (Division of Nuclear Education and Training) to administer related activities.
- Equipment grants valued at $2.3 million were made to 213 educational institutions during the year, and $940,000 worth of nuclear materials were loaned without charge to 32 colleges and universities.
- A combined total of over 2,800 faculty members, graduate students, and undergraduate students received nuclear training through institutes, fellowships, and special training courses under AEC sponsorship during the year.

Contracting Policy

- Small business concerns received 45.9 percent of the total dollar value of subcontract awards in Commission activities as compared with the 39.3 percent average for the period 1951–61.

Industrial Relations

- A study of trends in employment showed that between 1956 and 1961 there was an increase of 58 percent in the number of scientists and engineers, combined, working in the U.S. atomic energy field.
- Separate employment and occupational data for Government-owned and for privately owned industrial establishments are presented in this Annual Report. Heretofore, information of this type was incorporated in the aggregate data for Government-owned and privately owned plants.
- Establishment of a Labor-Management Advisory Committee provides a forum which brings together representatives of organized labor, management, and AEC to discuss problems, procedures, and requirements in connection with radiological aspects of industrial safety.



First State. The Commonwealth of Kentucky was the first state to assume certain portions of the Atomic Energy Commission's regulatory authority over the use of radioactive materials within the state. The agreement was formally signed on February 8, 1962, and became effective on March 26. Since then California, Mississippi, and New York have also signed agreements with the Commission. Photo shows, left to right, John B. Breckinridge, Kentucky Attorney General; Governor Bert Combs of Kentucky signing the agreement; AEC Chairman Glenn T. Seaborg; Chairman Chet Holifield of the Joint Committee on Atomic Energy; and Woodford B. McCool, Secretary to the Commission, during the February 8 ceremony.

Part Five—Regulatory Activities

- The Commission issued its first license for burial of low-level radioactive wastes by a private firm on State-owned land.
- Permits were issued for the construction of one power reactor, two research reactors, and a critical experiment facility. Provisional operating licenses or other authorizations were issued for seven power reactors, seven research reactors, and a critical experiment facility.
- The Commission received its first application for a construction permit and facility license to operate a spent fuel reprocessing plant.
- The use of Atomic Safety and Licensing Boards was instituted to speed up licensing procedures.
- Agreements were signed with four States—Kentucky, California, Mississippi, and New York—under which the Commission relinquishes certain of its regulatory authority to the States.

Part One
Commission Actions

ACTIONS IN SUPPORT OF INDUSTRY AND SCIENCE

The Atomic Energy Commission has the statutory responsibility to promote the nation's atomic energy program by encouraging the participation of United States industry and science in the continued growth and development of the overall nuclear field. During 1962, the Commission made a number of policy and programmatic decisions aimed at enhancing the developmental program while, at the same time, assuring that any changes brought about would not create undue hazards to the public health and welfare and would not be adverse to the national defense and security.

During 1962, the Commission continued to emphasize its program of encouraging participation by industrial, scientific, and other private organizations in atomic energy work.

GENERAL POLICY STATEMENT

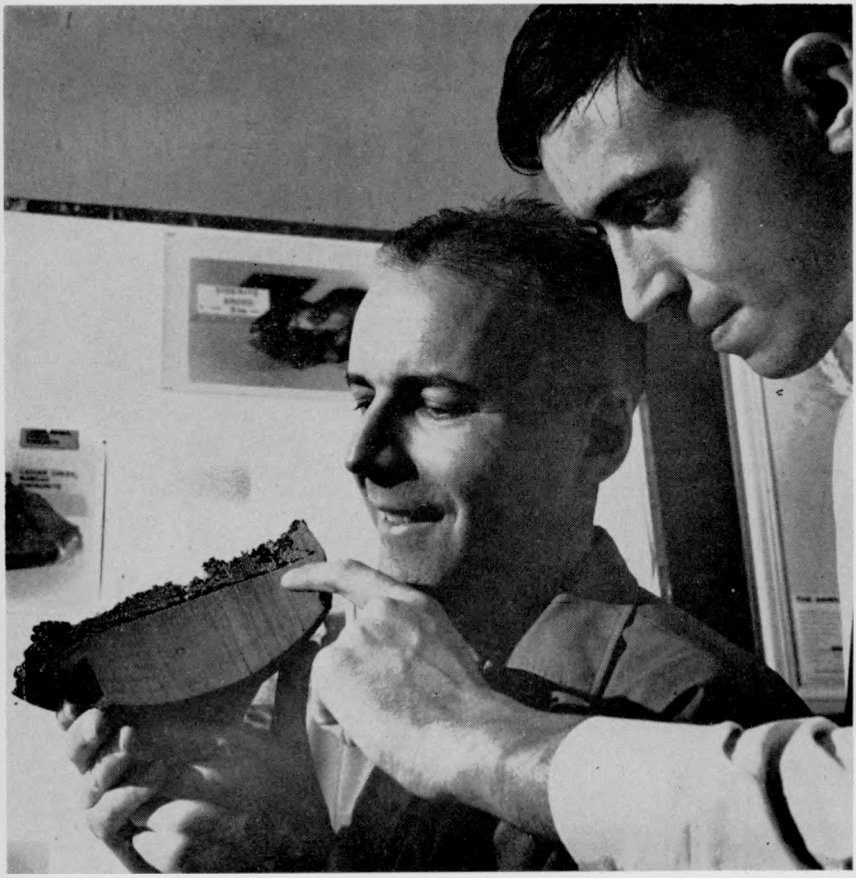
At the start of the year, the Commission issued a statement summarizing broad guides for staff use in programs of industrial participation. The statement provided a consolidation and clarification of earlier instructions to the staff and continued in effect the general policies which have guided Commission activities in industrial participation in the past.

The two basic industrial participation policies are:

1. That affirmed by the Atomic Energy Act of 1954, as amended, which states that, subject at all times to the paramount objective of making the maximum contribution to the common defense and security, "the development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise".
2. The Federal policy which is in favor of Government procurement from private sources unless a finding is made that compelling reasons exist for performing work in Government-owned facilities. Compelling reasons for exceptions to the general policy include national security, relatively large and disproportionately higher costs, and clear unfeasibility. This Federal policy requires Government agencies to discontinue activities currently performed in Government-owned facilities if, and when, commercial facilities are available to do the job at reasonable cost.

The Division of Industrial Participation, established in May 1961 to, among other responsibilities, provide a focal point for industry

within the AEC [1] continued during 1962 to review industrial capabilities in nuclear work to determine whether gaps exist in commercial activities which would offer additional opportunities for private participation and investment in the development and utilization of atomic energy for civilian purposes and for the support of Government



Sputnik Remains. During the year, the Commission's Los Alamos Scientific Laboratory, N. Mex., aided in determining that a 20-pound chunk of metal that fell on the streets of Manitowoc, Wis., on September 5 was part of a Russian satellite. Photo shows a sawed-off part of the chunk of metal. A 16-hour test with an extremely sensitive low-level radiation crystal counter showed, through the presence of the radioisotope manganese 54, that the specimen had recently returned from space. The radioisotope had been created by cosmic ray-induced gamma radiation. The intensity of the radioactivity, however, was not as high as in a freshly-fallen iron meteorite which was subjected to the same radiological tests at Los Alamos. The rough metal on the upper side of the specimen indicates that the metal melted and flowed from the heat of reentry into the earth's atmosphere. The chunk was tentatively identified as a part of the Sputnik IV satellite which had been launched on May 15, 1960.

[1] See pp. 39–40, "Annual Report to Congress for 1961."

programs. The Division also assisted commercial organizations in plans to bridge existing gaps by assuring the availability of information necessary to such undertakings.

Toward the end of the year, arrangements were being developed, in cooperation with industry representatives, on ways of correlating financial information with program and technical information so that the financial impact of announced AEC programs on the nuclear industry could be more specifically evaluated.

SPECIFIC ACTIONS

During the year, a wide variety of actions—ranging from price reductions to changes in regulatory policy—were made by the Commission. The following pages concern some of the more important actions.

Further Reduction in Enriched Uranium Charges

The Commission again revised its base charges for enriched and depleted uranium, effective July 1, 1962. This revision consisted of a reduction in the component of charge for the work of separating uranium isotopes. The estimated effect of the change is to lower the cost of nuclear power by one-tenth to one-quarter of a mill per kilowatt-hour for most types of enriched reactors.

For enriched uranium, the new schedule incorporates a 12 percent reduction in base charges at high enrichments, a 10 percent reduction at a uranium 235 (U–235) assay of 3 percent, and an 8 percent reduction at 2 percent U–235. There is a related increase in base charges for depleted uranium of certain assays. Table No. 1, below, gives examples of the new base charges and comparisons with previous charges. When the 1962 revision is combined with the one made in 1961 [2]—which involved a reduction in the component of charge for natural uranium—the overall result is a reduction in charges varying from 30 to 40 percent for enriched uranium and from 40 to 55 percent for depleted uranium, depending on the U–235 content.

Operations improvements. The reduction in the charge for "separative work" was made possible by improvements in the economics of operation of the gaseous diffusion plants at Oak Ridge, Tenn.; Paducah, Ky.; and Portsmouth, Ohio.

The revised schedule of base charges will apply to foreign as well as domestic users. The Commission, however, may in the future add to the schedule of base charges for enriched uranium distributed abroad under contracts for sale or lease entered into after July 1, 1962, a

[2] See pp. 44–45, "Annual Report to Congress for 1961."

moderate surcharge in those cases where the United States will thereby incur costs for safeguarding the material against diversion from peaceful uses.

Further studies. As in the case of the 1961 revision, the new schedule of base charges for enriched and depleted uranium does not affect present commitments by the Commission regarding prices for plutonium and uranium 233 through fiscal year 1963. Studies are in progress within the AEC to determine appropriate prices for these reactor products after FY 1963. These studies are supported by computations at AEC laboratories with the objective of estimating the value of plutonium and uranium 233 as fuel in nuclear reactors. The Commission has indicated that the estimated near-term fuel value of plutonium is still not less than $8 per gram for typical reactor-grade material (in the form of nitrate). The establishment of future prices for plutonium and U–233 is related to consideration of private ownership of special nuclear material (see below).

Private Ownership of Special Nuclear Materials

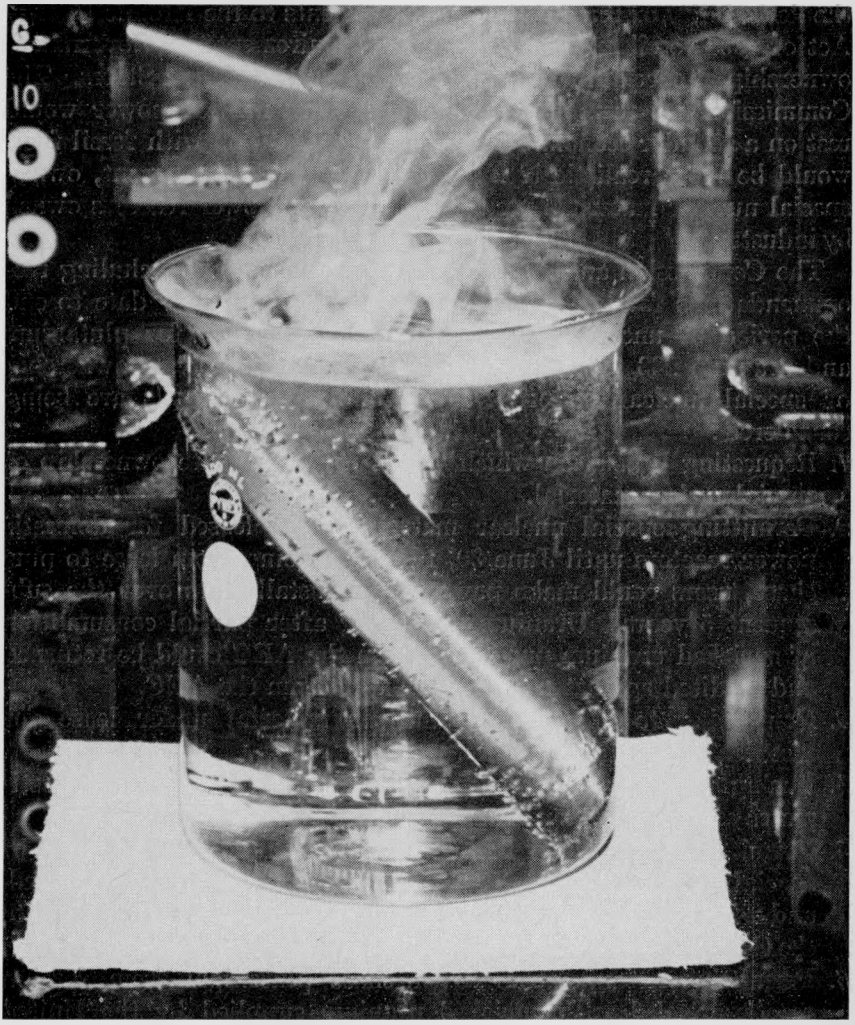
As stated in the announcements of the 1961 and 1962 revisions of the schedule of charges for enriched uranium and in AEC testimony before the JCAE on March 21, 1962, consideration is being given to

TABLE 1.—EXAMPLES OF BASE CHARGES FOR ENRICHED AND DEPLETED URANIUM AS URANIUM HEXAFLUORIDE

U–235 assay in weight percent	New charges		Previous charges	
	Dollars per kilogram of contained uranium [a]	Dollars per gram of contained U–235	Dollars per gram of contained U–235	
Enriched uranium				*Percent reduction*
90	10,808.00	12.01	13.65	12
20	2,252.00	11.26	12.74	12
10	1,062.00	10.62	11.95	11
5	479.40	9.59	10.71	10
3	254.30	8.48	9.37	10
2	146.50	7.33	8.00	8
1.5	95.30	6.35	6.84	7
1.0	47.70	4.77	4.99	4
Depleted uranium				*Percent increase*
0.7	22.60	3.23	3.23	0
0.6	15.35	2.56	2.47	4
0.5	8.90	1.78	1.61	10
0.4	3.70	0.93	0.75	24
0.38 [b]	3.00	0.79	0.79	0

[a] Official base charges.

[b] If a user specifies a U–235 assay between 0.38 and 0.22 weight percent, the charge will be $3 per kilogram of contained uranium. However, if the U–235 assay is not specified by the user, the AEC will supply uranium having a U–235 assay to be determined by the AEC in the range below 0.38 percent and will charge $2.50 per kilogram of uranium.



Hot Plutonium. Plutonium 238 is being used as a heat source for the thermoelectric generators in the Navy's TRANSIT navigational aid satellites. These heat sources are fabricated at the Commission's Mound Laboratory, Miamisburg, Ohio, and then shipped to the Martin-Marietta Corp. facility at Baltimore, Md., for incorporation into the AEC's SNAP (Systems for Nuclear Auxiliary Power) units. Photo shows a plutonium 238 heat source fabricated for a SNAP–9A unit which will be aboard a TRANSIT satellite to be launched in early 1963. The heat from the radioactive decay is enough to boil the beaker of water. Mound Laboratory is operated for the Commission by the Monsanto Research Corp.

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the desirability of recommending amendments to the Atomic Energy Act of 1954 to eliminate the statutory requirement for Government ownership of special nuclear material within the United States. The Commission has reemphasized its belief that nuclear power would rest on a sounder economic base and its competition with fossil fuels would be more realistic if industry, instead of government, owned special nuclear materials used or produced in power reactors owned by industry.

The Commission anticipates that specific proposals, including recommendations for legislation, can be made at an early date to end the period of uncertainty concerning future prices for plutonium and uranium 233 (U–233) and future plans for private ownership of special nuclear material. The following proposals are being considered:

1. Requesting legislation which would permit private ownership of special nuclear material.
2. Permitting special nuclear material to be leased for domestic power reactors until June 30, 1973. In going from lease to purchase, users could make payments in installments over the subsequent 5 years. Uranium remaining after partial consumption of enriched uranium purchased from the AEC could be returned and credited against further purchases from the AEC.
3. Continuing to offer special nuclear material under lease for research and medical reactors.
4. Basing guaranteed prices for plutonium and U–233 on AEC estimates of their values as fuel in nuclear reactors.
5. Permitting payment of higher prices for plutonium or U–233 of special quality for which the Commission might have special need, and which it could not otherwise be assured would be delivered to the Commission.
6. Permitting arrangements to purchase plutonium from foreign reactors fueled with enriched uranium supplied by the United States at the same price and during the same period as for guaranteed purchase of plutonium from domestic reactors.

Prices of Useful Fission Products Reduced

New processes and increased production capacity at its Hanford, Wash., and Oak Ridge, Tenn., reprocessing and purifying plants led the Commission to sharply reduce the prices of fission product cesium 137 and strontium 90 during the year. The new prices, effective as of March 20, 1962, for cesium 137 are 50 percent lower than previously, and the price of strontium 90 was cut to from 13 to 20

TABLE 2.—NEW AND OLD PRICES FOR CESIUM 137 AND STRONTIUM 90

(New Prices effective as of Mar. 20, 1962)

CESIUM 137

Former Price Schedule

0–20,000 curies	$2/curie or fraction
20,000–100,000 curies	$1.50/curie
Over 100,000 curies	$1/curie

New Price Schedule

0–20,000 curies	$1/curie or fraction
20,000–100,000 curies	$0.75/curie
Over 100,000 curies	$0.50/curie

STRONTIUM 90

Former Price Schedule

0–500 curies	$10/curie or fraction
500–5,000 curies	$7.50/curie
Over 5,000 curies	$5/curie

New Price Schedule

0–5,000 curies	$2/curie or fraction
5,000–30,000 curies	$1/curie
Over 30,000 curies	$0.75/curie

NOTE: The revised price schedule for strontium 90 is based on a strontium carbonate product; however, the Oak Ridge National Laboratory will quote, upon request, prices for strontium 90 titanate and strontium 90 chloride. The cesium 137 is in the form of cesium chloride powder.

percent of its former level. The old and new prices are compared in Table 2.

The two fission product radioisotopes were first made available in millicurie quantities in 1947. Reflecting increases in production capacity and efficiency over the years since, a series of price reductions has resulted which has seen the price of cesium 137 drop to less than 1/250,000th of its initial price. Similarly, the price of strontium 90 has dropped to about 1/2,000th of its original level.

"Spent" fuel recovery. Fission products are radioisotopes salvaged from radioactive waste during the processing of "spent" nuclear reactor fuel elements. Cesium 137 and strontium 90 are being recovered from the waste streams at the Hanford Plant, and are being purified and packaged into the form suitable for end uses at the Commission's Oak Ridge National Laboratory. Strontium 90 is also being packaged under contract to the AEC at Quehanna, Pa., in the Martin-Marietta Corp. facility.

Heat and radiation sources. Both strontium 90 and cesium 137 are being used increasingly as heat and radiation sources. The Commission plans to separate and purify megacurie quantities of strontium 90 and cesium 137 to assure their ready availability for use in programs utilizing thermoelectric generators such as those used in the Systems for Nuclear Auxiliary Power (SNAP) program. A thermoelectric generator directly converts the heat produced by radioactive decay into electricity. A current major use of strontium 90 is to power automatic unmanned Arctic and Antarctic weather stations. The isotopic power sources of these stations are able to function unattended for about 10 years.

Strontium 90 and cesium 137 are also promising sources of radiation for nuclear applications such as manufacture of chemicals and production of polymers. Additionally, cesium 137 is well suited for sterilization of medical supplies, for preservation of food, and is being used currently for medical therapy.

Prices Adjusted for Radioisotopes

Prices for a number of radioisotopes used for industrial, medical, and research purposes were adjusted by the Commission during the year.

Price reductions, effective as of February 15, included those for the widely used radioisotope carbon 14 and iodine 131 as well as technetium 99, krypton 85, chlorine 36, thallium 204, and sodium 24. As a further incentive to the use of radioisotopes by medical, research, and industrial groups, the new schedule provides discount prices for multicurie quantities of carbon 14, iodine 131, krypton 85, and thallium 204.

Higher prices for bromine 82, calcium 45, copper 64 and gold 198 were established to recover actual increases in production costs.

The reduction in the price of carbon 14 was from $9.50 per millicurie to $7.50 per millicurie (mc) in quantities of one curie or less. The last price reduction for this radioisotope had been announced in August 1960. The new price for quantities over one curie is $6.50 per millicurie. These price changes will be of major interest to research scientists who have been making sharply increased use of this versatile radiocarbon. During calendar year 1961, a record amount of 41 curies of carbon 14 was distributed under the Oak Ridge National Laboratory's radioisotopes sales program.

The price changes are shown with the former prices in Table 3. These prices are subject to change from time to time as determined by the Commission.

These radioisotopes are produced and distributed by the Commission's Oak Ridge National Laboratory.

TABLE 3.—RADIOISOTOPE PRICE ADJUSTMENTS

(Effective Feb. 15, 1962)

Radioisotope	Old price	New price
Carbon 14	$9.50 per millicurie (/mc)	$7.50/mc for one curie or less. $6.50/mc over one curie.
Technetium 99	$100 per gram	$90 per gram.
Krypton 85	$50 per curie 1 to 2 curies	
	$15/c excess of 2 c	$15/c for 50 curies or less. $10/c 51 to 1,000 curies. $7.50/c, 1,001 curies or more.
Iodine 131	$0.40/mc to 199 mc	$0.35/mc, 0 to 200 mc.
	$0.35/mc 200 to 499 mc	$0.31/mc, 201 to 500 mc.
	$0.30/mc 500 or more mc	$0.28/mc, 501 to 1,000 mc. $0.26/mc, 1,001 to 1,500 mc. $0.25/mc, 1,501 to 2,000 mc. $0.24/mc, 2,001 to 3,000 mc. $0.23/mc, 3,001 to 4,000 mc. $0.20/mc, over 4,001 mc.
Bromine 82	$0.50/mc	$3.75/mc.
Calcium 45	$6.50/mc	$12/mc.
Copper 64	$0.80/mc	$1.10/mc.
Gold 198	$0.06/mc	$0.20/mc for 500 mc or less. $0.06/mc for over 500 mc.
Sodium 24	$7/mc	$5/mc.
Chlorine 36 [a]	$500/mc	$325/mc.
Thallium 204 [a]	$1/mc	$1/mc, 0 to 4,999 mc. $0.60/mc, over 5,000 mc.

[a] The changes in prices for chlorine 36 and thallium 204 had become effective during December 1961.

Withdrawal from Activation Analysis Work

The Commission, in accordance with its policy to discontinue providing materials and services which are reasonably available from commerical sources, withdrew as a supplier of routine activation analysis services, effective March 1, 1962, since activation analysis procedures are now being performed routinely in a number of research and commerical laboratories.

Neutron activation analysis is capable of great sensitivity and accuracy, with concentration determinations in parts per million. The analysis is accomplished by exposing a sample of the material to be tested to a flux of neutrons, which makes some atoms of each chemical element present in the sample become radioactive. Each element then can be identified by its radiation characteristics. Currently, neutron activation analysis is being applied as an analytical technique in medicine, to determine trace materials in tissues; in industry, to analyze oil well cores, to determine trace impurities in petroleum prod-

ucts, chemicals, and semiconductor materials; and in geology, oceanography, agriculture, meteorology, public health, and other scientific areas for a variety of tests.

The Oak Ridge National Laboratory will continue to provide special activation analysis to private concerns where the service is not otherwise available. The Laboratory has pioneered in developing many aspects of neutron activation analysis and has served as a focal point for both national and international interests in this modern nuclear method. The Commission will continue its program of research in activation analysis both at the Laboratory and with other research groups in advanced nuclear analytical technology.

Sales Withheld

Based on market impact studies and recommendations made by the Business and Defense Services Administration, the AEC, during October, agreed to withhold sales of yttrium, lithium, and vanadium pentoxide until the market situation improves. Until further notice, any proposed sales of any forms of these materials will require special Commission clearance in advance of any sales announcement.

Plutonium Chemical Standard Made Available

The Commission, in cooperation with the National Bureau of Standards, has prepared a plutonium chemical standard for use by educational and research institutions and industry in the United States and abroad. Having a purity of 99.97 percent plutonium, the sample contains several isotopes of plutonium, the principal one being plutonium 239. The sample (NBS Standard Sample No. 949) can be used as a comparison standard for all plutonium chemical analyses.

Development of standard materials of accurately known composition with which to base measurements with a high degree of accuracy has long been a major interest to users of atomic energy materials. The considerable expansion in recent years in the uses of atomic energy has underlined the need for standard materials which will be widely accepted.

Cooperative effort. To meet this demand, the Commission, with the aid of committees drawn from industry, has cooperated with the National Bureau of Standards to establish a continuing program for providing the needed standard materials. The first results of the AEC–NBS cooperation program were a series of 15 different uranium isotopic standards and a natural uranium chemical standard which became available from the Bureau on October 1, 1958.



Young Scientist. William E. Murray, Jr., of Rockville, Md., was one of ten 1962 National Science Fair-International (NSF–I) exhibitors winning AEC Special Awards for their outstanding exhibits related to nuclear science. His exhibit dealt with varying decay rates of radioactive isotopes. After returning from the NSF–I competition at Seattle, Wash., young Murray visited the Commission's Headquarters at nearby Germantown, Md., to discuss his work and future with AEC scientists. He is shown here receiving his AEC Certificate of Achievement from Commission Chairman Glenn T. Seaborg.

Half-gram weight. The plutonium chemical standard was produced at the AEC's Los Alamos Laboratory in New Mexico. Three standardization methods were used to evaluate the purity of the material. Results from all three methods were in close agreement.

Each plutonium standard issue unit consists of about one-half gram of plutonium metal sealed in a glass ampoule under a reduced argon atmosphere. The exact weight of each sample is etched on the ampoule.

Standards supplied by NBS are available [3] for $34, express collect, in the United States only to persons licensed by the Commission and to AEC contractors. Standards are available to foreign countries whose governments have appropriate agreements for cooperation with the United States.

"Heavy Element" Isotopes Made Available

The Commission made two "heavy element" radioisotopes, neptunium 237 and americium 241, available for sale to its licensees and for export. The principal use for neptunium 237 is as a component of neutron detection instruments. Americium 241 is used principally in sources for neutron-activation analysis—a technique for using neutron irradiation in the analysis of materials. It may be used also in portable X-ray type applications and for checking the calibration and performance of radiation detectors.

An initial allotment of 200 grams of each radioisotope was offered for sale [4] from Oak Ridge National Laboratory. Per gram prices are $1,500 for americium 241, and $500 for neptunium 237. Less than gram quantities may be purchased at $1.50 per milligram of americium 241, and $0.50 per milligram of neptunium 237, plus handling and shipping charges. Not more than 10 grams will be made available to any one licensee without approval from the Commission.

Export of Americium 241 Approved

During October, the Commission approved the export of the radioisotope americium 241 to be used in an international program for comparison of the measurement of radioactivity.

The National Bureau of Standards, Washington, D.C., was authorized to make the export in cooperation with a program sponsored by the Bureau Internationale des Poids et Mesures, Sevres, France.

National standardizing laboratories throughout the world, including Soviet bloc nations, will participate in the program of making comparison measurements of radioactivity, including the disintegration rate of americium 241. Other nations, including the Soviet Union, are supplying additional radioisotopes for use in the program.

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[3] Domestic orders must be placed on order form NBS–285 which may be obtained from the National Bureau of Standards, Washington 25, D.C. Orders from foreign sources should be submitted on form NBS–285A (also obtained from NBS) to the Division of International Affairs, U.S. Atomic Energy Commission, Washington 25, D.C.

[4] Domestic sales and export of these transuranium elements are subject to the Commission's byproduct materials (radioisotope) licensing regulations (10 Code of Federal Regulations, Part 30). Inquiries on such regulations should be addressed to the Director, Division of Licensing and Regulation, U.S. Atomic Energy Commission, Washington 25, D.C. Inquiries about purchasing procedures, product specifications, shipping and delivery dates, etc., should be addressed to the Isotope Sales Department, Oak Ridge National Laboratory, Oak Ridge, Tenn.

The radioactive americium will be distributed as microcurie standardized samples to participating laboratories with a limit of five microcuries to any one country. In authorizing issuance of an export license to the National Bureau of Standards, the Commission pointed out that the material exported has no strategic or military value. The National Bureau of Standards indicated that results of the comparison studies will be made public when they are completed.

Tritium Lock Illuminators Approved

The Commission amended its regulations to establish criteria for the manufacture and installation of automobile lock illuminators, each containing up to 15 millicuries of the radioisotope tritium. The amendment also establishes criteria for the import of these lock illuminators.

Beta radiation from tritium acts upon phosphors to provide luminosity. There is no detectable external radiation from the lock illuminator. The tritium used in the lock illuminator is in the form of paint completely sealed in plastic.

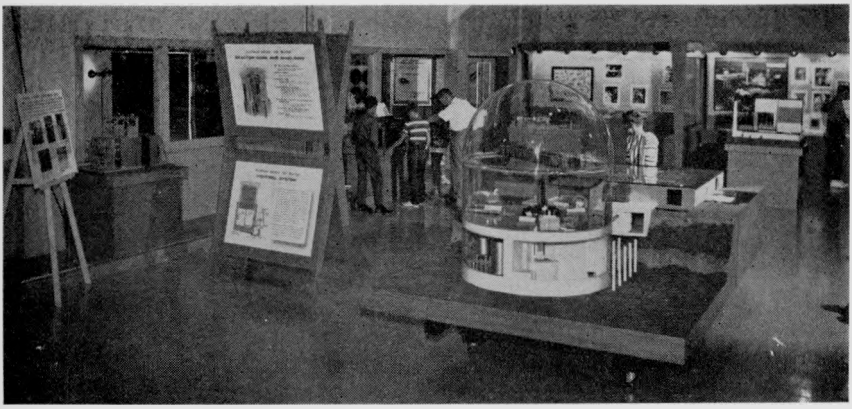
Tritium Aircraft Safety Signs

The Commission also amended its regulations to establish a general license [5] authorizing the possession and use in aircraft of luminous safety devices containing not more than four curies of radioactive tritium in each device. The general license will encourage wider use of the devices in aircraft, and contribute to the safety of the occupants. It permits use of tritium for luminosity in such aircraft safety devices as switch plungers, control markers, and exit signs in the event of failure of the airplane's electrical system.

The Commission continues to exercise regulatory control through its specific licensing procedures over the manufacture and import of luminous safety devices containing tritium for use in aircraft, and over the export of these devices. When installed in aircraft, the devices may be exported under general licenses to any country except that a specific license is required for export to Cuba or a Soviet bloc country.

Before any device can qualify for distribution to generally licensed users, the manufacturer or importer must apply to AEC for a specific license to distribute it, and must submit information to the Commission for evaluation of the safety aspects of the product.

[5] A general license is one for which the licensee need not apply to the Commission. It is granted under conditions set out in AEC regulations. A specific license requires an application and formal action by the AEC.



Tourist Attractions. As a part of its program to assist the economic growth of Richland, Wash., the Commission opened a visitor's center, part of which is shown *above*, at its Hanford plant in mid-1962. During its first four months of operation, the center drew some 30,000 visitors. One of the features of the center has been the scale model of the Plutonium Recycle Test Reactor (PRTR), *below*. In addition to the center, the Commission plans to permit pre-arranged bus tours through the Hanford Plants area under controlled conditions and to provide a tourist observation station at the PRTR.



Actions Having a Bearing on Reactor Programs

During the year, the Commission took a number of actions that will have a bearing upon the promotion of nuclear reactors for the generation of electricity. These actions are in line with the Commission's statutory responsibilities for furthering the construction and operation of nuclear power plants while, at the same time, providing for the health and safety of the public.

Reactor Site Criteria Guides Approved

During April, the Commission announced the approved criteria which it will use to guide its evaluation of proposed sites for stationary power and test reactors licensed by AEC. The Commission developed the guides so that industry, State, and local officials, and the general public, will be familiar with the factors which are considered by the AEC in judging proposed sites for reactors. The guides were published in the *Federal Register* of April 12, 1962. A reference booklet [6] for use in site calculations was also published.

The guides reflect an attempt to provide an objective basis for reactor siting to the extent that current reactor technology allows, but do not eliminate entirely the continued need for subjective judgments both by applicants for reactor permits and licenses and by the Commission. The criteria have been established as guides for the interim period until enough experience can be accumulated with reactors to provide a more definitive correlation of factors pertinent to the question of reactor siting and to permit the writing of more definitive standards. Sufficient flexibility has been included in the guides to allow for this orderly evolution of siting standards as the industry progresses. The guides were developed by the Commission in consultation with its Advisory Committee on Reactor Safeguards and following discussions with industrial groups.

New Reactor Research Program

A new research program which could lead to reductions in the cost of nuclear power reactors is being considered by the Commission. The program would be conducted in privately owned central station power plants. The AEC will conduct exploratory talks with the owners of various reactor plants to determine their interest in the program and to develop possible contractual arrangements for their

[6] "Calculation of Distance Factors for Power and Test Reactor Sites," TID–14844, available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for $1.

participation. The first such talks were held with officials of the Yankee Atomic Electric Co. regarding use of the Yankee plant at Rowe, Mass., in this program.

The program will seek to determine whether any reactor components have been overdesigned for safety and reliability; identify areas for improving performance characteristics; and obtain technical data which could possibly lead to decreases in capital, fuel, operating and maintenance costs. This information can be obtained only from special tests in operating power reactors and from the analysis of operating data.

The information would be widely disseminated under AEC control and would be of general benefit to the nation's overall reactor development program. A program similar to the new program for privately owned reactors is planned for the power reactors owned by the Government.

Nuclear Safety Program Expanded

The Commission has expanded its nuclear safety program for land-based and aerospace reactor systems to include engineering proof tests of nuclear components and systems to provide a more complete and experimentally verified basis for evaluation of their safety and reliability. Responsibility for carrying out the terrestrial program, announced on March 9, has been assigned to Phillips Petroleum Co., one of the Commission's contractors at the National Reactor Testing Station in Idaho. Sandia Corp. has been assigned the overall responsibility for conducting the Commission's aerospace safety work.

Hazard extent. The objective of the expanded program is to demonstrate, particularly under abnormal operating conditions, the safety performance characteristics of nuclear reactor systems. The program will seek to ascertain the adequacy of safety features and to provide further information on the potential hazard from fission products released in a reactor accident.

In the past, justifications for safety features of reactor systems have often been developed by analytical techniques and by relating laboratory and experimental data to full-scale reactor operations. The new program is expected to develop more experimentally verified definitive information on these safety features.

Status review. Current work involves review of the status of programs related to nuclear safety, the development of detailed recommendations for the proof-testing program and formulation of plans for the conduct of field tests. These tests are expected to include the

actual destruction of irradiated fuel elements and entire cores to determine what happens during a nuclear excursion or a loss of coolant involving melting of the core.

Remote tests. Precautions are taken during all tests of this nature for the protection of operating personnel and the public. The tests are conducted in remote areas and under favorable meteorological conditions, with operating personnel housed in a control center a safe distance away from the nuclear experiment.

Destructive tests are approached gradually with a carefully planned and executed series of experiments to determine what to expect in the final test. Data from each test in the series are analyzed and evaluated before the next test is made.

Direct examination. Another phase of the program is the direct examination of the capability of reactor pressure vessels and containment systems to withstand pressure and contain radioactive fission products.

Phillips will also be responsible for conducting experiments and excursion tests related to the ground safety of reactors designed as auxiliary electric power sources for space use. The company is presently conducting reactor safety experiments for the AEC in the Special Power Excursion Reactor Test (SPERT) plants at the National Reactor Testing Station. Objective of the experiments is to find basic explanations for the behavior of reactors under runaway conditions. The extreme conditions simulated in these experiments would not normally occur in operating power reactors. A series of core destructive tests in the SPERT–1 reactor facility has been conducted and on November 5, 1962, the core was destroyed by an excursion on a 3.3 millisecond period.

Reactor Safety Book Under Preparation

A contract was awarded during March to the Massachusetts Institute of Technology (MIT) at Cambridge, Mass., under which MIT will direct the preparation of a comprehensive manuscript on nuclear reactor safety. Approximately 20 experts on reactor safety—from universities, industry, and AEC contractor organizations—will participate in the project.

The manuscript will deal with technical factors bearing on safety in the design, construction and operation of nuclear reactors. Subjects to be covered include reactor containment, fission product release, retention and disposal; reactor fuels, materials and metallurgy; reactor core design and steady-state power behavior; reactor kinetics;

heat transfer and fluid flow; mechanical systems; instrumentation and controls; chemical reactions and criticality.

The Commission expects the manuscript to be valuable for use in both its own program of reactor operation and in its regulatory program under which privately-owned reactors are licensed, as well as to industry. The project is being administered by the Commission's Division of Technical Information which sponsors the preparation of books and monographs needed to advance nuclear science and technology. The Commission's Divisions of Licensing and Regulation, Reactor Development, and Operational Safety also participate in the project.

Shielding Evaluation Center Established

A radiation shielding evaluation center was established during the year at the Commission's Oak Ridge National Laboratory to assist in solving radiation problems related to reactors, nuclear weapons, and space. The center will collect, evaluate, and will compile a bibliography of current shielding information supplied by industrial and educational organizations involved in shielding studies. Particular attention will be devoted to digital computer codes developed for solving shielding problems. Progress will be reported in a periodic newsletter to be widely distributed. The center will also answer special inquiries or furnish appropriate references or copies of pertinent information.[7]

Initially, the center will provide information on shielding against radiation from reactors. Long range plans include dissemination of information on shielding from high-energy radiations including those found in space and from nuclear weapons effects.

An advisory board comprised of members selected from organizations having significant radiation shielding problems will guide the overall program of the center.

Atomic Licensing and Safety Boards

During November, the Commission initiated procedures designed to permit greater flexibility and to encourage informality in the conduct of licensing proceedings. The new procedures, put into effect as a result of 1962 legislative amendments to the Atomic Energy Act of 1954, provide for: (*a*) use of three-member Atomic Licensing and Safety Boards to conduct licensing proceedings rather than the single

[7] Organizations interested in the services of the center should write to: E. P. Blizard or S. K. Penny, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tenn.

Hearing Examiner used heretofore; (*b*) dispensing with the mandatory public hearings at the operating licensing phase of a reactor licensing proceeding; and (*c*) lessening the number of amendments to reactor construction permits or operating licenses referred to the Advisory Committee on Reactor Safeguards.

First Board use. The first use of the three-man board was for the public hearing held at Lynchburg, Va., on December 10 to consider issuance of a test reactor construction permit to Babcock & Wilcox Co. A second three-man board was scheduled to hold a hearing on January 3 to consider authorizing initial operation of the Enrico Fermi Fast Breeder Reactor at Lagoona Beach, Mich., by Power Reactor Development Co. A board also will be established to consider the application of Allis-Chalmers Manufacturing Co. for an authorization to construct the La Crosse power reactor at Genoa Station, Wis.

Each atomic safety and licensing board established by the Commission will include three members, two of whom will be technically qualified and one who is qualified to conduct administrative proceedings. These boards will conduct those public hearings which are referred to them by the Commission and make either intermediate or final decisions, depending upon the authority granted by the Commission, in proceedings involving granting, suspending, revoking, or amending of licenses or authorizations. The Commission also is authorized to delegate to such a board other regulatory functions which the Commission deems appropriate. Members of the panel appointed thus far from which the Commission will draw members for the Boards is listed in Part Five—Regulatory Activities of this report.

Informal process. Hearings in which there are no contested issues will be conducted with the maximum degree of informality consistent with due process and other legal requirements. Informal hearing procedures will be used on applications concerning power and test reactors when there are no intervenors and when the applicant, the Commission's regulatory staff, and the Advisory Committee on Reactor Safeguards are in substantial agreement as to the issuance and provisions of the appropriate permit. The Commission will reassess these informal proceedings after they have been used a sufficient number of times.

The amendments to the Atomic Energy Act of 1954 were signed into law by the President on August 29, and include a provision that the Advisory Committee on Reactor Safeguards will be required to review only such amendments to a construction permit or an operating license as are specifically referred to it at the discretion of the Commission.

Spent Fuel Processing Option

Under a change of procedure announced in early December, operators of licensed reactors now have the option, under certain conditions, of making deliveries of irradiated reactor fuel to the Atomic Energy Commission by transferring the spent nuclear fuel elements to the AEC and storing them for the AEC at the reactor sites. Previously, only the Commission's processing plants in Idaho and South Carolina were designated as receiving sites for spent fuel elements.

When the deliveries are made, whether at the reactor or at AEC receiving sites, financial settlement will be made with AEC, including its charges for chemical processing and conversion, in accordance with existing Commission policies.

Site storage. The reactor operators will also have the option, under terms to be negotiated, of making arrangements to have the stored fuel elements, previously transferred to the AEC, processed by a private company when and if such a company becomes licensed to perform chemical reprocessing operations. Storage of spent fuel at the reactor sites would avoid reshipment from an AEC site for any such fuel to be processed in a private facility.

First deliveries. The Commission is discussing prospective arrangements with operators of two reactors who have indicated preliminary acceptance of the optional arrangement for delivery of this spent fuel to AEC at the respective reactor sites. They are Commonwealth Edison Co., operator of the Dresden Nuclear Power Station near Morris, Ill., and Yankee Atomic Electric Co., operator of the Yankee Nuclear Power Station at Rowe, Mass. First fuel loadings from these two reactors are scheduled to be delivered to the AEC before June 30, 1963. Under the proposed arrangement the companies would store the spent fuel at the reactor sites and the AEC would make provisional financial settlements with the companies in accordance with announced principles.

The AEC leases reactor fuel to licensed operators in the United States. Under these leasing arrangements, the Commission charges the user for the uranium 235 which is consumed. The Commission is required, however, to pay the operator a fair price for the fissionable material—such as plutonium 239—which is produced in the course of reactor operations and delivered to AEC. The financial settlement will include appropriate credits to the reactor operator to reflect the production of such materials.

Transportation of Radioactive Materials

Safe transportation of all categories of radioactive materials is vital to the successful growth of the nation's nuclear energy program, not only from the standpoint of public health and safety but also on an economic basis. Obviously, overly restrictive safety regulations can make transportation so costly as to make operations involving radioactive materials uneconomical. On the other hand, regulations which are so relaxed as to inadequately protect the health and safety of the public could result in a serious accident which would interfere with the proper development of nuclear energy for peaceful purposes.

During 1962, the Commission broadened its own continuing transportation safety program, and initiated an expanded education and orientation program designed to cover all facets of transporting radioactive materials, and, concurrent with this, sponsored a number of meetings with groups concerned with transportation of radioactive materials to exchange ideas based on specific handling and transport problems in anticipation of future increases in the transportation of large, highly-radioactive sources, *e.g.*, more and more irradiated "spent" fuel elements being transported from reactor sites to processing plants.

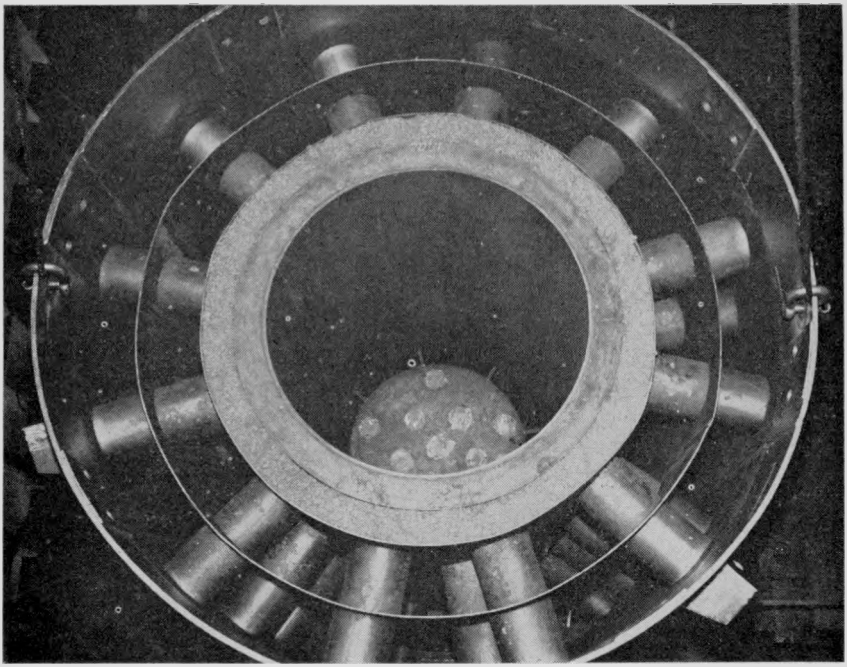
The Commission's program in the transportation of radioactive materials area is a coordinated effort involving a number of Headquarters divisions and field agencies.

Radioactive Materials Shipments Survey

Results of a comprehensive survey made by the AEC regarding shipments of radioactive materials by its contractors and licensees showed that: (*a*) over a 16-year period there has been no record of a radiation injury from such shipments; (*b*) small quantities—less than 20 curies [8] of radioactive material—make up more than 80 percent of the shipments; and (*c*) 58 percent of the shipments made by licensees are by air since most of the radioisotopes shipped have a short half-life. The survey was made as a part of an interagency effort to develop technical standards for transportation of radioactive materials.

Approximately 109,000 shipments of various radioactive materials were made during the 6-month period October 1, 1961 through

[8] A curie is the standard unit of radioactivity and is defined as the quantity of radioactive material in which the number of disintegrations per second is 37 billion. A microcurie is one millionth of a curie.



Buffered Container. This is the interior of a "HAPO II" cask container used in transporting strontium 90 recovered from fission product wastes at the AEC's Hanford, Wash., plant to Oak Ridge National Laboratory, Tenn., for processing into isotopic heat sources. The strontium 90 shipping cask itself fits into the opening in the center of the cask container. The container consists of four concentric steel shells separated by rubber buffers. Buffers are also used in the spaces above and below the cask. As a result, the cask can easily withstand heavy bumps and decelerating forces during rail transport. Newer models of the cask container are being modified by General Electric Co., engineers to use aluminum honeycomb as the energy absorption medium. This improves the cold weather energy absorption characteristics of the cask container, and will permit shipment under severe winter time conditions.

March 31, 1962. Primarily the shipments were of types typically used in industry, research, and medicine. These ranged from small shipments of less than 10 microcuries of material to shipments involving more than 50,000 curies. The survey did not include shipments of nuclear weapons or weapons components.

Safety record. The safety record of both AEC contractors and licensees making shipments of radioactive materials continues to be excellent. In the 16-year history of these shipments there is no record of a radiation injury in the transportation of radioactive materials. A study of transportation accidents involving shipments originating from AEC or AEC contractor operated facilities during the period 1957 through 1961 showed that of 47 incidents reported involving

radioactive materials, 29 involved no release of radioactive material. None of the 18 cases in which there was a release of radioactive material involved serious consequences or extensive decontamination.

Contents of shipments. Of the 85,607 shipments reported by firms licensed by AEC during the 6-month period covered by the 1961–62 survey, 78,233 shipments reported contained less than 20 curies of radioactive material. During that same period, 12,000, or 51 percent, of 23,500 shipments reported by Commission contractors also contained less than 20 curies.

The survey showed that Commission contractors are making the bulk of large quantity radioactive material shipments. For example, during the survey period, the AEC contractors made 180 shipments which exceeded 5,000 curies. During the same period, only 12 such shipments were made by Commission licensees.

Shipping means. Fifty-eight percent of the 85,607 licensee shipments were made by air, 20 percent by truck, 14 percent by rail express, 3 percent by rail freight, 2 percent by regular mail, and 3 percent by other means. The large percentage of air shipments is indicative of the growing use of radioactive materials with a short radioactive half-life, such as iodine 131 which has an 8-day half-life and is used extensively for medical purposes.

Truck shipments compose the largest number made by AEC contractors. Of the 23,500 shipments made during the 6 months period surveyed, 35.6 percent went by truck, 25.3 percent by air, 24 percent by railway express, and 15.1 percent by rail freight.

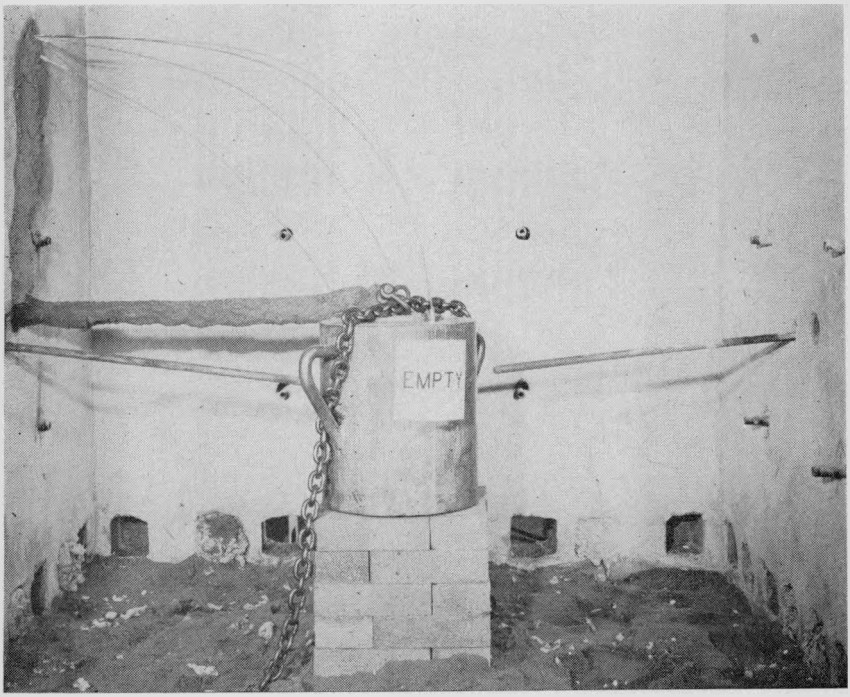
Packaging criteria. The survey was made by AEC in order to obtain a current picture of the number and quantities of shipments of radioactive materials being made so that this information can be related to the packaging criteria now under study by the Inter-Agency Committee on Transportation of Radioactive Materials.

This committee, composed of representatives of the Interstate Commerce Commission, the Coast Guard, Federal Aviation Agency, Post Office Department, Bureau of Explosives, and the AEC, has developed and circulated for public comment Draft Technical Standards for the Transport of Radioactive Materials. These standards would be used as the basis for revising present Federal regulations.

Transportation Accident Experience

A study of the AEC accident experience in transporting radioactive materials during the 5 years 1957–61 was made and published.[9] It was found that 47 incidents occurred during this 5-year period, but

[9] A Summary of Incidents Involving USAEC Shipments of Radioactive Material—1957–1961, TID–16764, available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for $0.75.



Fire Test. Photo shows an empty radioisotope shipping container in position and instrumented for measurement of effects of a rigid fire test. Tests have been conducted for the Commission by Underwriters' Laboratories, Inc., Chicago, during the past year and have revealed points where improvements can be made in container design. In addition to fire tests, containers were subjected to drop and other impact tests to determine their sturdiness under all conceivable conditions. Purpose of the tests is to assure that the container will retain its radioactive contents under all environmental conditions.

in 29 (61 percent) of the cases there was no release of radioactivity. Of the remaining 18 cases, which did involve radiation releases, none presented any serious consequences or caused costly cleanup. The following table shows the incident experience by mode of transit or location:

INCIDENT EXPERIENCE BY MODE OR LOCATION

Mode or locations	*Number of incidents*
Truck Incidents	21
Terminal Incidents	15
Rail Incidents	11
Total	47

AEC Operations Experience

As a subpart of the above overall transportation study, a survey was made of the 5-month shipping experience by the AEC's con-

tractor-operated facilities. The figures for the October 1961–March 1962 period were then converted to an annual basis. It is felt that this reasonably represents the AEC's current shipping experience.

SUMMARY OF ANNUAL AEC SHIPMENT OF RADIOACTIVE MATERIALS

	Number	*Percent Total*
Total number of shipments	47,000	100.0
Shipments requiring Type "A" packaging [a]	24,000	51.0
Shipments requiring Type "B" packaging [b]	21,000	44.7
Shipments exceeding curie limits specified in revised technical standards [c]	3,760	8.0
Shipments by mode of Transport		
Truck	16,500	35.6
Rail Freight	7,000	15.1
Railway Express	11,100	24.0
Air	11,800	25.3

[a] Type A packing is adequate to prevent loss or dispersal of radioactive contents and to retain shielding efficiency under normal conditions of transport.

[b] Type B packaging is adequate to prevent loss or dispersal of radioactive materials and to retain shielding efficiency under normal conditions and under severe accident conditions.

[c] These shipments require, prior to actual shipment, approval of containers by the Bureau of Explosives as agent for Interstate Commerce Commission (ICC).

Port Clearances for Radioactive Materials

Although shipments of radioactive material to and from the United States have been averaging about 250 annually for the past several years, this material has had relatively low levels of radioactivity. The future return of highly irradiated spent fuels from abroad for reprocessing or other disposition makes it necessary that efforts be concentrated on assuring that this traffic can be handled with maximum safety and dispatch, through the ports.

During 1962, the first clearances of U.S. ports for the movement of highly irradiated materials through their facilities and environs for international shipment were made. As a result of meetings between the AEC staff and port authorities, five cities submitted resolutions to the Coast Guard during 1962 declaring their readiness to accept highly irradiated material: Charleston, S.C., Savannah, Ga., Norfolk, Va., Seattle, Wash., and Philadelphia, Pa. Discussions are continuing with officials representing other major ports which are expected to grant similar clearances during 1963.

Orientation Program

During the year, an expanded education and orientation program was undertaken by the Commission to reach interested industry groups concerned with problems related to the transportation of radioactive

materials. This program has as its objective, the dissemination of information to transportation interests so that shipments of radioactive materials will be accepted on the same basis as other hazardous cargoes. Information regarding indemnity, transportation regulations, and shipping characteristics of radioactive cargoes has been assembled and will be provided to interested groups. Concurrent with this action, representatives of AEC continued to conduct meetings and seminars with groups concerned with transportation of radioactive materials to exchange ideas based on specific handling and transport problems.

The AEC has been cooperating with other agencies of the Government and representatives of both foreign and domestic industries in a broad program of education designed to acquaint the public with the facts concerning the handling of radioactive materials.

Orientation meetings held with East Coast, Gulf, and West Coast port officials led to five ports obtaining Coast Guard approval for the handling of high level radioactive materials—Charleston, Savannah, Norfolk, Philadelphia, and Seattle.

The Commission has participated in two forums on ocean transport of radioactive materials—the first in July 1961, at San Francisco, and the second in January 1962, in New York City.

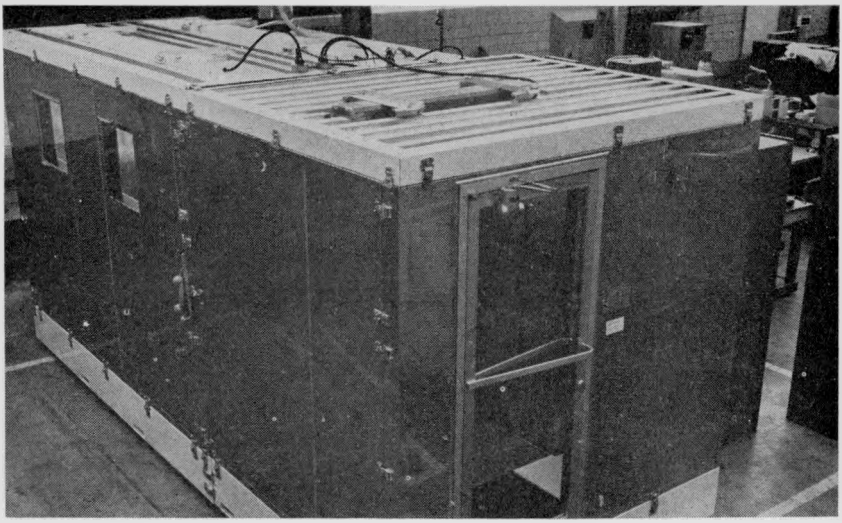
In addition, the AEC has co-sponsored with the Interstate Commerce Commission regional meetings in Atlanta, San Francisco, New York City, and Chicago. These meetings were held to discuss with State and local officials general transportation and safety proposals in the handling of radioactive materials.

Orientation meetings where held with port officials of Fort Lauderdale, Fla.; New Orleans, La.; Houston, Tex.; and Wilmington, N.C., during November and December. These meetings were sponsored jointly by the AEC and the Southern Interstate Nuclear Board.

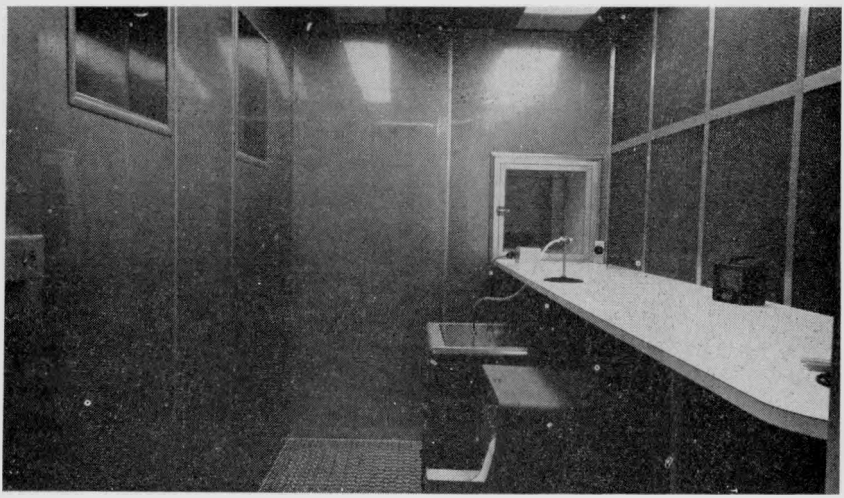
State Regulations

During the summer of 1962, members of the American Bridge Tunnel and Turnpike Association provided information to the Commission with respect to regulations of their respective State agencies covering the transportation of radioactive material. A tabulated summary of the information received from 47 of the 61 members is as follows:

No specific regulations in effect	32
Use ICC or modified regulations	11
Prohibitory or restrictive regulations in effect	3
Referred to other State agency	1
TOTAL	47



Improved Clean-Room. A portable clean room, *above*, providing an atmosphere many times cleaner than that previously attainable has been designed by Sandia Laboratory which is attracting widespread interest from industry. Dust-particle counts indicate the room creates a work-area environment 1,000 times cleaner than that possible in the most efficient clean rooms previously developed. The efficiency of the new chamber results from its unique airflow pattern. Clean air enters the room through a 4-x-6-foot bank of absolute filters directly over the work bench, *photo below*. The filters are 99.97 percent efficient in removing particles 0.32 micron and larger. The clean air passing over the work area carries away dust particles generated within the room before they can settle on the work bench. The air then passes into the floor's coarse air filters, and is then recirculated through air-conditioning and blower systems and the absolute filters housed in the walls of the room.



Industrial Capability

One of the basic objectives of the Atomic Energy Commission is to foster and support private, competitive participation in the nation's nuclear program.

As a result of the Commission's industrial participation policies, private industry has developed a capability to provide most of the materials and services needed in the use of atomic energy for peaceful purposes with only three important exceptions:

1. The enrichment of uranium with the fissionable isotope uranium 235 (U–235) will probably remain a Government monopoly into the foreseeable future because of the enormous investment required for a gaseous diffusion plant.
2. At present, the chemical processing of used fuel to retrieve the remaining useable materials is not being done by industry primarily because substantial private needs for this service are only now being generated as private nuclear power plants come into operation. A private group, Nuclear Fuel Services, Inc., has filed an application to construct such a plant, with initial operation planned in late 1965.
3. The third exception is the storage of high-level wastes, currently being accomplished only by the Federal Government, since high-level wastes are now generated only in Government plants. However, with prospective operation of a privately owned chemical processing plant, which will generate high-level wastes of its own, it seems reasonable to look forward to private operation of high-level waste storage sites under Government regulation on State-owned land.

Industry Categories

In connection with the implementation of AEC policies and practices related to the industrial impact of atomic energy, the Commission's Division of Industrial Participation, has developed a categorization of the nuclear industry. This was developed with the cooperation of industry organizations active in atomic energy affairs. The industry was divided into eight major segments. Under each segment, products and services are being studied with the objective of achieving a balanced, competitive, and self-sustaining nuclear industry in the United States. The categorization and a related more detailed listing of products and services are included in Appendix 4. It is probable that this industry categorization will be revised from time to time as experience may dictate and as the atomic energy industry may develop.

At the end of the year, efforts were being concentrated on ways of more specifically describing those industrial activities that are dependent on atomic energy applications for their well being and growth, and on the establishment of a systematic program for collecting information which will permit more complete reporting on the state of the industry.

In the interim, on the basis of available information, the eight major segments of the nuclear industry are reviewed below with an assessment of private capability now available in each segment and some conclusions on the viability of the organizations working in these fields.

Raw Materials (Category 1)

The exploration, mining, and milling of uranium ores are being accomplished by private industry. Of the 24 operating uranium mills, all privately owned, 22 are covered by Commission procurement contracts extending to December 31, 1966, and 2 have earlier termination dates because of limited supplies of eligible ore.

The Commission recently announced a new program for domestic uranium procurement from January 1, 1967 through December 31, 1970. The new program consists of a deferral to 1967 and 1968 of a portion of the material now contracted for delivery to the Commission before 1967 and the purchase, during the period 1969–70, by the Commission of an additional quantity equal to the amount deferred. Whereas, under the present 1962–66 program, deliveries had been expected to range from about 14,000 tons to 17,000 tons of uranium oxide annually through 1966, annual receipts will be reduced to the extent quantities of uranium are deferred. This program should provide a basis on which uranium producers looking to the future can extend their operations.

Materials Processing and Fabrication (Category 2)

Uranium feed preparation and enriching. Only one private facility is in operation and no additional private facilities are planned in this segment of the nuclear industry. The one privately owned facility is the Allied Chemical plant at Metropolis, Ill., which converts normal uranium oxide (U_3O_8) to uranium hexafluoride (UF_6). These are essential steps in the preparation of enriched reactor fuel on which other segments of the nuclear industry are heavily dependent.

Production of uranium hexafluoride (UF_6) is accomplished at the Commission's plants at Paducah, Ky., (UO_3 to UF_6), Weldon Spring, Mo., (UO_3 to U_3O_8), and at the privately owned Allied Chemical plant. Enrichment of normal UF_6 with the uranium 235 (U–235) isotope is now accomplished only in Government owned gaseous diffusion plants at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio.

Uranium processing. Industrial capacity exists today to convert normal, depleted, and enriched UF_6 to metal and various uranium compounds. However, very few of the processors are producing at or near their capacities. Private capability and competition in the processing of uranium appear adequate for industry needs.

Although future needs for processing services in the licensee program are expected to decline over the next few years, military and space requirements are expected to increase, thus resulting in a net increase in work for this segment of the industry over the next several years.

Almost all uranium metal for use in the production-weapons program, the Naval program, and for test reactors at the National Reactor Testing Station, Idaho, is produced in AEC facilities. The industrial and non-production-weapons program needs for metal have been declining and are expected to continue to decline over the next several years.

Unlike uranium metal, almost all uranium oxide is produced in privately owned facilities. The demand for oxides and other compound forms is increasing and may continue to increase over the next several years.

Nine firms have capability for converting UF_6 to forms needed for fabrication of fuel elements.[10]

Commercial conversion of UF_6. For the past 4 years, nearly all enriched uranium provided for nonproduction/weapons uses has been supplied as uranium hexafluoride (UF_6) for further processing in commercial plants. In 1956 all uranium for nonproduction/weapons uses had to be processed beyond the hexafluoride stage in Commission facilities. The growth of commercial capability in this segment of the industry is reflected year-by-year in the following table.

[10] The nine firms are (italicized indicates a licensed facility): Coors Porcelain Co., Golden, Colo.; *Davison Chemical Co., Erwin, Tenn.;* General Dynamics Corp., San Diego, Calif.; Minnesota Mining & Manufacturing Co., St. Paul, Minn.; National Carbon Co., New York, N.Y.; National Lead Co., Albany, N.Y.; *Nuclear Materials & Equipment Corp., Apollo, Pa.; Spencer Chemical Co., Pittsburg, Kansas* (Nuclear operations of Spencer have recently been taken over by Kerr-McGee.); *United Nuclear Corp., Hermatite, Mo.* (Unlicensed facilities do conversion work only under contract to the AEC.)

ENRICHED URANIUM FURNISHED TO INDUSTRY

	Fiscal years (kilograms of uranium)						
	1956	*1957*	*1958*	*1959*	*1960*	*1961*	*1962*
Furnished as UF_6	0	6,000	24,000	110,300	86,200	118,400	125,000
Furnished* in forms other than UF_6	2,400	4,000	21,000	6,300	3,400	6,900	3,000
TOTAL	2,400	10,000	45,000	116,600	89,600	125,300	128,600

*Primarily for AEC programs.

Fabrication of uranium fuel elements. Seventeen firms [11] produce various types of fuels and shapes from metal and compounds, including newer types. In general, the fabrication field is highly competitive with a number of fabricators utilizing a high percentage of their capacities.

Quantities of uranium utilized outside of the production-weapons field have been steadily increasing. Although this trend is expected to continue, changes in the firms in this field due to competition and changing fuel types may be expected.

AEC orders for fuel from industry. Orders placed by the Commission on commercial suppliers of fuel in the 1962 fiscal year were nearly double the value of such orders placed in the prior fiscal year and were substantially above those placed in any earlier year.

AEC ORDERS FOR NUCLEAR FUEL FROM COMMERCIAL SUPPLIERS

	Fiscal year (millions of dollars)			
Orders placed for:	*1959*	*1960*	*1961*	*1962*
Naval purposes	$38.6	$48.6	$29.2	$60.9
All other purposes	2.8	3.8	4.0	4.5
TOTAL	41.4	52.4	33.2	65.4

Thorium, U–233, plutonium. Present needs for these materials for peaceful uses are very limited and essentially of a developmental nature. Nonetheless, thorium is processed by seven firms [12] and can be fabricated in facilities which can fabricate uranium.

[11] The 17 firms in the uranium fabrication area are (italicized indicates a licensed facility) : *Aerojet-General Nucleonics, San Ramon, Calif.;* Atomics International, Canoga Park, Calif.; *Babcock & Wilcox Co., Lynchburg, Va.; Battelle Memorial Institute, Columbus, Ohio; Carborundum Co., Niagara Falls, N.Y.; Combustion Engineering, Windsor, Conn.; Davison Chemical Co., Erwin, Tenn.; General Dynamics Corp., San Diego, Calif.; General Electric Co., San Jose, Calif.; Martin-Marietta Co., Baltimore, Md.; Metals and Controls, Inc., Attleboro, Mass.; National Lead Co., Albany, N.Y.; Nuclear Materials & Equipment Corp., Apollo, Pa.; Nuclear Metals, Inc., Concord, Mass.; Sylvania Electric Products, Inc., Hicksville, N.Y.; United Nuclear Corp., New Haven, Conn.; Westinghouse Electric Corp., Pittsburgh, Pa.*

[12] The principal firms processing thorium are: American Potash & Chemical Corp., West Chicago, Ill.; Davison Chemical Co., Erwin, Tenn.; Dow Chemical Co., Midland, Mich.; Metal Hydrides, Inc., Beverly, Mass.; National Lead Co., Albany, N.Y.; United Nuclear Corp., Hematite, Mo.; Vitro Corp. of America, New York, N.Y.

Uranium 233 (U–233) can be processed by Davison Chemical Co., Erwin, Tenn., and can be fabricated by Atomics International, Canoga Park, Calif. Babcock & Wilcox is currently erecting a facility at Lynchburg, Va., which will have both laboratory and pilot plant capabilities for working with U–233.

Plutonium can be processed and fabricated to a limited extent by Nuclear Materials and Equipment Corp., Apollo, Pa., and can also be fabricated by United Nuclear Corp., White Plains, N.Y., and Battelle Memorial Inst., Columbus, Ohio. In addition, Monsanto Research Corp., Dayton, Ohio, and Nuclear Materials and Equipment Corp., Apollo, Pa., have facilities for the fabrication of plutonium-beryllium neutron sources, alpha sources, threshold detectors, and the like. The Carborundum Co., Niagara Falls, N.Y., has filed an application for a license covering the pelletizing of both plutonium and uranium carbide into ceramic type fuel.

Nonfuel materials. Generally, private industrial capacity exists for the production, processing and fabrication of the various nonfuel materials associated with atomic energy work (*i.e.*, control materials; moderator and reflector materials; coolants; cladding and matrix materials; and shielding materials).

A few materials, boron 10, enriched lithium 6 and 7, and heavy water are produced only in Government-owned facilities. The feasibility of obtaining boron 10 from private industry is now under study. A complete evaluation of the industry has not been attempted in the nonfuel materials area since, for the most part, this segment of industry is not primarily dependent upon atomic energy work.

Beryllium. Representatives of seven commercial organizations interested in beryllium production and fabrication met with the Commission's staff in October for an exchange of information to assist the industry in its advance planning. AEC programs and estimates of AEC requirements were presented, forms in which beryllium is needed and critical specifications were discussed, AEC plans to utilize beryllium scrap were explored, and the AEC research and development effort in the beryllium field was described. Similar meetings (on this or other subjects) are expected to be held in the future whenever a need arises for such an exchange of information.

Nuclear Components and Equipment (Category 3)

All nuclear components and equipment are now available commercially, and there is no substantial competition between AEC and private industry in furnishing items falling within this category.

General nuclear equipment, considered entirely in the light of data reported by the Bureau of the Census,[13] is maintaining a year-to-year increase in use, although the rate of increase was lower for 1961 than for the year before.

The reactor component business, and particularly the reactor fuel business, is influenced significantly by orders for Naval propulsion purposes. An upturn in orders placed for Navy cores during the 1962 fiscal year, the continuing high level of the Navy nuclear construction program, and continued increases in nuclear research and development expenditures, would indicate 1962 levels for the reactor components business at close to levels experienced during 1960–61.

Reactors (Category 4)

Although the reactor business has attracted a large number of firms to the field, the major portion of the business is concentrated in a limited number of firms. Appendix 7, Nuclear Reactors Built, Being Built, or Planned in the United States, credits more than 25 commercial organizations as being the "principal nuclear contractor" on one or more of the 350 or so reactors listed. However, 298 of these reactors have been attributed to the organizations listed on Table 4. The number of reactors attributed to each and the total capacity in terms of thermal megawatts of power is also shown.

At mid-1962, 53 reactors of all types were under design or construction in the United States. The total estimated cost of these reactors was $1,310 million compared with an estimated cost of $1,361 million for the 65 reactors under design or construction a year earlier. These estimates are based on quarterly surveys conducted by the Commission. The surveys cover all civilian, Army and Navy land-based plants, AEC materials production reactors and plants in the Maritime program. A listing of reactors included in the surveys appears in Appendix 5.

Of the 65 reactors under design or construction on June 30, 1961, 17 were completed by June 30, 1962. Of these, eight were civilian research or teaching reactors, four were military prototypes or field plants, two were for military testing or research, one was for civilian testing, one was for the NS *Savannah*, and one was a civilian power experiment.

Of the 53 reactors under design or construction as of June 30, 1962, five were started during the preceding year. Four of these were for civilian research and teaching and one was a civilian power experiment.

[13] See table on page 68.

TABLE 4.—REACTORS BUILT OR UNDER WAY

	Number of reactors					Approximate total Mwt
	Production	Civilian power [a]	Military [b]	Other [c]	Total	
Advanced Tech. Labs. (Am. Std.)				7	7	(*)
Aerojet-General			4	19	23	5
Allis-Chalmers [d]		3	5	7	15	650
AMF Atomics				21	21	55
Argonne National Laboratory			1	15	16	200
Atomics International		2	2	18	22	360
Babcock & Wilcox		2		8	10	1,130
Combustion Engineering—						
Navy			2		2	(**)
GNEC		1		2	3	50
DuPont	8			5	13	(**)
General Atomics		1	2	24	27	125
General Electric—						
Hanford	6			3	9	(**)
KAPL [e]			12	0	12	(**)
Commercial		7		15	22	2,600
Lockheed			1	4	5	10
Los Alamos Scientific Laboratory				9	9	30
Martin-Marietta			3		3	65
Oak Ridge National Laboratory				10	10	160
United Nuclear				1	1	(*)
Westinghouse—						
Bettis [e]		1	81		82	(**)
Commercial		6		2	8	3,260

Reactors in the ROVER, SNAP, PLUTO, and ANP programs have not been included.

[a] Excludes experimental reactors. Includes reactors for export and NS *Savannah*.

[b] Including land-based prototypes, experimental, test, and research reactors.

[c] Includes research, training, test, and experimental reactors.

[d] Includes Alco-Products and ACF whose nuclear business has been absorbed by Allis-Chalmers.

[e] As reactor designer.

*Negligible.

**Classified.

Costs incurred during the year on these reactors totaled $304 million compared with $335 million during the preceding year. The backlog of costs remaining to be incurred was estimated at $419 million compared with a backlog of $533 million a year earlier.[14] The lower levels for the 1962 fiscal year reflect progress toward completion of civilian power prototype plants and lack of new starts in this category during 1961–62. However, at the year's end, a number of new proposals were under consideration and indicated an upward trend in new starts in future years.

In terms of estimated costs incurred annually, reactor projects of the type included in Tables 5 through 8 have accounted for about 40 percent of the total for all reactor work for each of the past 3 years. The survey excludes reactors for aircraft and space applications and for the propulsion of Naval vessels (but land-based Navy

[14] See p. 34, Annual Report to Congress for 1961.

TABLE 5.—DOMESTIC REACTOR PROJECTS UNDER DESIGN OR CONSTRUCTION

	At June 30, 1961		At June 30, 1962	
	Number of projects	Total estimated cost (millions)	Number of projects	Total estimated cost (millions)
All projects	65	$1,360.7	53	$1,310.4
Civilian reactor projects	52	955.8	46	986.5
Power prototypes and experiments	24	754.4	24	844.5
Civilian testing	7	113.8	6	85.8
Civilian research	20	59.3	16	56.2
Merchant ship propulsion	1	28.3	----	----
Military reactor projects (land-based plants only)	12	222.0	6	123.4
Military prototypes, experiments, and field plants	6	193.5	2	102.3
Military testing and research	6	28.5	4	21.1
Materials production reactors	1	182.9	1	200.5

TABLE 6.—COSTS INCURRED DURING FISCAL YEARS 1961–1962

	Costs incurred	
	Fiscal year 1961 (millions)	Fiscal year 1962 (millions)
All projects	$334.8	$303.5
Civilian reactor projects	222.3	196.7
Power prototypes and experiments	186.8	169.6
Civilian testing	19.1	12.1
Civilian research	9.6	10.6
Merchant ship propulsion	6.8	4.4
Military reactor projects (land-based plants only)	54.5	38.9
Military prototypes, experiments, and field plants	50.4	35.8
Military testing and research	4.1	3.1
Materials production reactors	58.0	67.9

TABLE 7.—COSTS AND ESTIMATES BY SOURCE OF FUNDS

	Costs incurred fiscal year 1962 (millions)	Projects active as of June 30, 1962		
		Total estimated costs of projects (millions)	Cumulative costs incurred thru June 30, 1962 (millions)	Estimated costs to be incurred after June 30, 1962 (millions)
All projects	$303.5	$1,310.4	$891.2	$419.2
Source of funds:				
Federal Government	203.6	863.9	519.1	344.8
Atomic Energy Commission	197.5	814.1	481.2	332.9
Department of Defense	4.2	25.0	21.8	3.2
Other Federal Agencies	1.9	24.8	16.1	8.7
Industry and others	99.9	446.5	372.1	74.4
Privately owned utilities	89.4	385.3	334.3	51.0
Publicly owned utilities	3.3	38.7	28.3	10.4
Manufacturers, universities, and States	7.2	22.5	9.5	13.0

TABLE 8.—COSTS AND ESTIMATES BY TYPES OF EXPENSE

	Costs incurred fiscal year 1962 (millions)	Total estimated costs of projects (millions)	Cumulative costs incurred thru June 30, 1962 (millions)	Estimated costs to be incurred after June 30, 1962 (millions)
Totals	$303.5	$1,310.4	$891.2	$419.2
Types of expense:				
Plant and equipment	212.9	937.9	643.4	294.5
Research and development	67.1	277.6	208.1	69.5
Fuel fabrication	15.3	61.3	24.1	37.2
Land and land rights	0.4	3.2	2.9	0.3
Training	5.0	12.4	7.6	4.8
Use charges waived	2.8	18.0	5.1	12.9

prototypes are included). Also excluded are general reactor research and development costs not related to specific reactor projects. Table 9 reflects the total for all reactor work. For the 1962 fiscal year this totaled $782 million. Although this represented a slight decrease below the comparable figure for fiscal 1961, it remained well above the 1960 figure.

TABLE 9.—TOTAL ESTIMATED COSTS INCURRED FOR ALL REACTOR WORK

	Fiscal year 1960 (millions)	Fiscal year 1961 (millions)	Fiscal year 1962 (millions)
Total of projects included in tables 5 through 8	$289.0	$334.8	$303.5
Naval reactors (research and development, nuclear portion of propulsion plants, and propulsion plant fuel)	144.1	149.7	161.5
Other military research and development (Army, aircraft, PLUTO)	104.4	106.6	*35.1
Space applications (ROVER, SNAP)	32.3	56.0	112.1
Other AEC civilian nuclear power research and development	63.5	59.3	67.8
All other AEC reactor development work (including nuclear technology and reactor safety)	81.4	85.6	102.3
Total—All reactor work	714.7	792.0	782.3

*The aircraft program was discontinued in 1961.

Radioisotopes (Category 5)

Commission facilities have been chiefly bulk suppliers of radioisotopes. About 40 commercial firms in the United States purchase quantities of radioisotopes and reprocess them into "packaged" radioactive pharmaceuticals, labeled radioisotope compounds, and sealed sources of radioactivity for resale to licensed purchasers in industry and research organizations. Other groups sell cyclotron-produced

and naturally occurring radioisotopes, stable isotopes, and radioisotopes produced in either foreign or privately owned reactors.

Seven [15] U.S. concerns manufacture medical radioisotope teletherapy machines. Eight [16] companies are prepared to encapsulate isotopes for these large radiation sources, and some can handle up to a million curies of cobalt 60. The Commission withdrew from providing cobalt 60 encapsulation service in March 1958 in favor of these private companies.

Commercial use of cobalt 60. The Dow Chemical Co. announced in November 1962 that the country's first commercial-size plant using ionizing radiation as a catalyst in a chemical production process would go into operation shortly after the first of the year. The plant, to be located at Midland, Mich., will produce ethyl bromide, an organic intermediate in the manufacture of a number of chemical and pharmaceutical compounds. A cobalt 60 gamma radiation source will be used, under a Commission license, in a new production process developed by Dow research scientists. It will act as a source of energy and cause the raw materials to combine to form ethyl bromide.

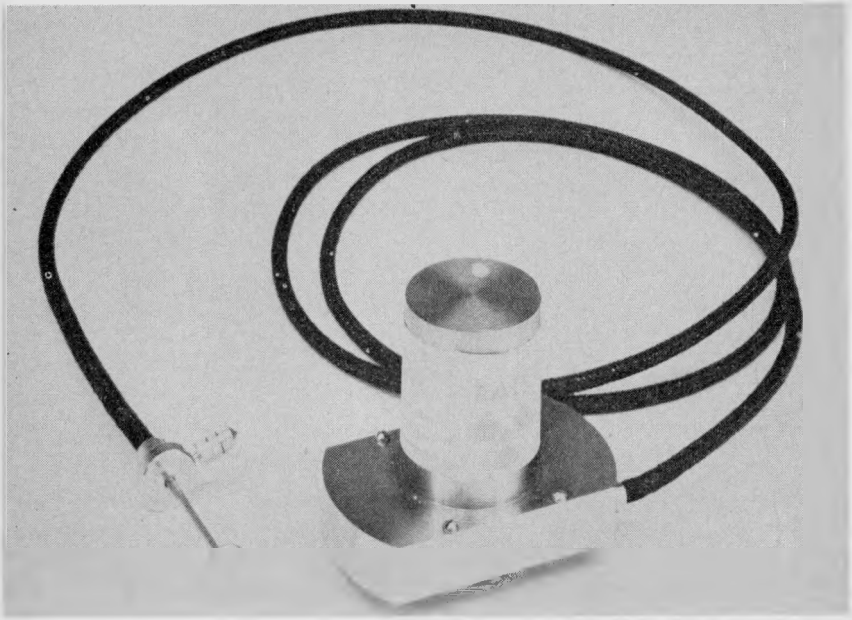
Dow examined all avenues of producing ethyl bromide—by chemical means, ultraviolet irradiation, and gamma radiation. From a strictly economic point of view, and for considerations of chemical purity, they decided to use ionizing radiation from a cobalt 60 source. The choice made by the company is a recognition of the economic benefits to be derived by use of massive nuclear radiation in industrial processing.

"Tagging" compounds. Prior to 1950, nearly all "tagged" compounds were prepared in Commission laboratories. In the fiscal years 1949 and 1950, the Commission gave financial assistance to the development necessary for synthesis of selected isotope-labeled compounds. After private groups had developed appropriate techniques and experience in preparing these materials, the Commission in 1955 withdrew entirely from providing them. Hundreds of differently

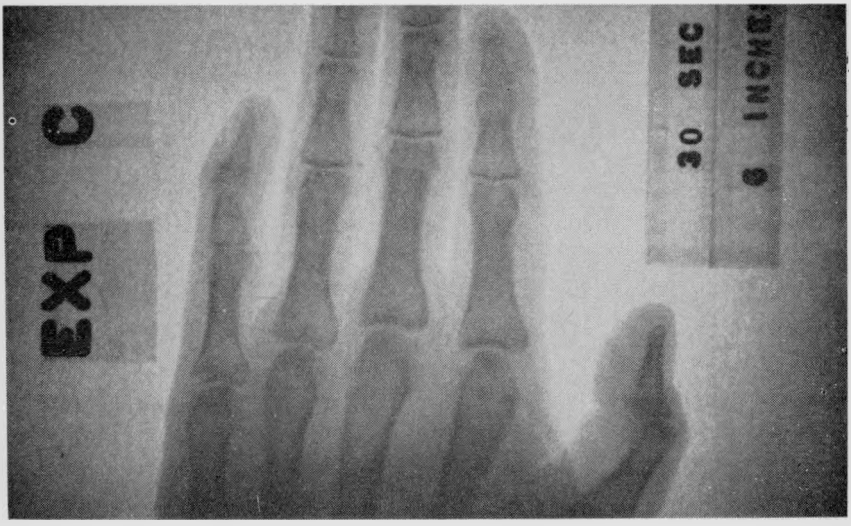
[15] Teletherapy machine manufacturers: Bar-Ray Products, Inc., Brooklyn, N.Y.; W. F. and John Barnes Co., Rockford, Ill.; Dick X-Ray Co., St. Louis, Mo.; General Electric Co., Milwaukee, Wis.; Tracerlab Div., Keleket X-Ray Corp., Waltham, Mass.; Waite Mfg. Div., Picker X-Ray Corp., Cleveland, Ohio; X-Ray Div., Westinghouse Electric Corp., Baltimore, Md.

[16] Commercial encapsulators: Admiral Corp., Chicago, Ill.; The Budd Co., Phoenixville Pa.; Gamma Industries, Inc., Baton Rouge, La.; General Electric Co., Pleasanton, Calif.; Nuclear Research Corp., Southampton, Pa.; Nuclear Materials & Equipment Corp., Apollo, Pa.; Nucledyne Division, Cook Electric Co., Franklin Park, Ill.; Waite Mfg. Div., Picker X-Ray Corp., Cleveland, Ohio; and U.S. Nuclear Corp. Burbank, Calif.

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Portable Radioisotope X-Ray System. A small X-ray system powered by promethium 147 and about the size of a cigarette package has been developed by Armour Research Foundation under an AEC contract. Photo *above* shows the source holder which can contain up to 250 curies of promethium 147 (2.5-year half-life) without external hazard. When the shutter is opened via the remote control cable, the beta-excited secondary X-ray emission is adequate to take a hand or foot radiograph in less than one minute. *Below* is an experimental radiograph of a human hand. The exposure was made with a 200-curie source for 30 seconds at a distance of six inches using the 3,000-speed Picker-Polaroid X-ray film system. This source-film system needs no chemicals, water, or dark room to process the exposed film.



tagged radiocompounds are now stocked and made routinely available by dozens of companies.

In March 1958, the Commission also discontinued providing gamma irradiation services to private groups. About 150 academic and industrial organizations in the United States have their own cobalt 60 irradiation facilities, and many offer such irradiation services on a Commercial basis.

Private production. The General Electric Co. for the past 3 years has been producing large quantities of cobalt 60, iridium 192, and iodine 131 in the General Electric Test Reactor (GETR) near Pleasanton, Calif. They have also advertised their capability to produce other processed and unprocessed isotopes such as thallium 204, thulium 170, carbon 14, phosphorus 32, tritium, chromium 51, and iron 59. Some commercial firms are now buying their radioisotopes from General Electric instead of from Oak Ridge National Laboratory, the Commission's major radioisotopes shipping center. At the time of shutdown of the Westinghouse test reactor at Waltz Mill, Pa., in March 1962, Westinghouse had produced and distributed large amounts of cobalt 60 and smaller quantities of other radioisotopes such as iridium 192. A number of low-flux reactors at universities and private companies are also being used to routinely produce short-lived radioisotopes.

Shipment values increase. The Bureau of the Census has reported that the value of radioisotopes shipped from privately owned plants producing isotopes increased from $73,000 in 1957 to $1,688,000 in 1961. Similarly the value of radiation sources and other radioactive materials produced from purchased isotopes rose from $2,722,000 to $4,559,000. Likewise, control and measuring devices containing radioisotopes increased from $6,007,000 to $10,500,000 in 1961.

In the last 10 years the value of isotopes imported into the United States has grown from $5,400 to about $1.5 million. These imports have come mainly from Atomic Energy of Canada, Ltd., and United Kingdom Atomic Energy Authority.

Private recovery of fission products. In 1961, at the invitation of the Commission,[17] a committee was designated by the Manufacturing Chemists' Association to determine if a basis now exists for private participation in the fission product isolation program. The committee was asked to review the work on fission product isolation which has

[17] See p. 45, Annual Report to Congress for 1961.

been done at various places in the Commission, to look in detail at the program at the Commission's Hanford plant, and to render an opinion as to whether industry is ready to take any part in this program at this time. The Committee's report with recommendations, submitted in mid-1962, represented the results of a 6-month study which included visits to Commission facilities at Oak Ridge, Savannah River and Hanford and discussions with both AEC and contractor personnel at those sites and at AEC Headquarters. At the end of the year the report and its recommendations were under study by the Commission. Factors which tend to discourage the entry of risk venture capital into this field on a commercial basis at this time include: uncertainties in process technology; uncertainties as to the future market for fission product heat and radiation sources and, in particular, the unlikelihood of a commercial market developing in the near future on a basis economically competitive with alternate energy sources; and the possibility that the source of supply (production reactor waste streams) would disappear if nuclear weapon production ceased. Nonetheless, it appears that some degree of commercial involvement may be possible.

Materials Reprocessing (Category 6)

Irradiated fuels. There is, at this time, no existing privately owned facility capable of processing irradiated fuels.

The AEC, however, has established charges for providing for processing of power reactor fuels at its facilities until June 30, 1967, unless a private facility, offering services on a reasonable basis, is available earlier. The charges established by the AEC for this service are based upon a conceptual plant design.

A private chemical processing plant is now being proposed by Nuclear Fuel Services, Inc., and is being designed to process power reactor fuels. Negotiations between Nuclear Fuel Services, the Commission, the utilities who would be its customers, and the State of New York where the plant will be located, are proceeding.

Unirradiated uranium scrap. Prior to fiscal year 1959, no private capability existed for the recovery of unirradiated enriched uranium scrap. However, as a result of the Commission's commercial uranium recovery program, industrial capability now exists to recover all of the various types of uranium scrap formerly recovered only by Oak Ridge, and at prices that are competitive with established AEC prices.

During the 1962 fiscal year, five firms [18] participated in this program. Orders placed during the year totaled $928,000, a reduction of about a third below the dollar value of awards for the prior year. Although this reduction was caused in part by problems in analyzing materials and fixing financial responsibility for the uranium content of scrap, it also reflects the generation of smaller quantities of scrap material than in fiscal 1961 and a reduction in unit prices charged for processing the scrap. Based on present projections, the quantities of scrap available for recovery are expected to increase over the next several years.

Plutonium. Except for limited laboratory facilities at Nuclear Material & Equipment Corp. (NUMEC), no private capability exists for the recovery of plutonium from scrap.

In 1961, the Dow Chemical Co. expressed an interest in the commercial recovery of plutonium from scrap generated in the Commission's production/weapons work.[19] Although the proposal was attractive in many respects, early in 1962 the Commission determined that it would not be desirable from the AEC's standpoint to commit itself to large scale private processing of scrap from its production/weapons program. It noted that there are certain avenues which could lead to commercial processing of some portions of AEC's plutonium scrap, however, and that these avenues would be explored. The Commission is proceeding with a study to determine the breadth of industrial capability necessary to provide a fully integrated plutonium processing service to support peaceful uses of atomic energy, the timing of establishment of this service, and the amount and form of Government participation which would most effectively satisfy AEC's policy responsibilities. As a part of this study, the extent of AEC activities in plutonium work will be reviewed and the existing capabilities of private industry will be determined.

Private power reactors already in operation will discharge fuel containing plutonium. This plutonium will be separated, reclaimed, and, ultimately, fabricated into fuel elements for use in power reactors. Private plutonium capability will thus be needed to meet these anticipated processing and fabrication requirements.

Studies undertaken in recent months show that private processing is practical, technology is available, shipments can be conducted safely (although the necessary shipping facilities are costly), and the costs of private facilities do not appear to be so great as to preclude private investment.

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[18] Davison Chemical Co., Erwin, Tenn.; Nuclear Materials and Equipment Corp., Apollo, Pa.; United Nuclear Corp., Hematite, Mo.; Englehard Industries Inc., Newark, N.J.; National Lead Co., Albany, N.Y. Englehard has recently withdrawn from this work.

[19] See p. 51, Annual Report to Congress for 1961.

Waste Disposal[20] *(Category 7)*

Certain low-level, packaged radioactive wastes may be disposed of by land burial or by sea burial. Five organizations in 1961 provided certain commercial waste disposal services by delivering wastes for burial at interim disposal sites on AEC-owned reservations in Idaho and Tennessee. The AEC is encouraging the development of State-owned disposal sites. Toward the end of 1962, one company (Nuclear Engineering Co., Pleasanton, Calif.) was licensed to dispose of low-level wastes on State-owned land in Nevada, and arrangements for disposal on State-owned land in Kentucky and New York were being made.

Seven additional companies are licensed to handle low-level, packaged wastes by delivery to AEC interim burial grounds or disposing of them at sea. Another company is licensed to dispose of such wastes at sea only. In addition, seven organizations are licensed to dispose of their own low-activity, packaged radioactive wastes at sea.

Since 1960, when the Commission established the interim disposal sites at Oak Ridge, Tenn., and the National Reactor Testing Station, Idaho, sea disposal of low-level wastes has been drastically reduced; however, a few facilities, because of their coastal locations, utilize sea disposal and will probably continue to use the oceans for this purpose. The majority of industry, however, finds it more economical to use land-burial methods.

High level wastes up to now have been generated and stored entirely at AEC-owned facilities.

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[20] As of Nov. 30, 1962, there were six organizations licensed to conduct commercial services involving the disposal at sea of low activity, packaged radioactive waste. No new organizations were licensed during 1962. The licensed firms are: American Mail Line, Seattle, Wash.; Allied-Crossroads Nuclear Corp. (formerly Crossroads Marine Disposal Corp.), Dorchester, Mass.; California Salvage Co., San Pedro, Calif.; New England Tank Cleaning Co., Cambridge, Mass.; Nuclear Engineering Co., Pleasanton, Calif. and Beatty, Nev.; and The Walker Trucking Co., New Britain, Conn.

With the exception of American Mail Line, the firms listed above are also authorized to conduct commercial waste disposal services by transfer to Commission-designated sites in Tennessee and Idaho for land burial. The following companies are authorized to conduct commercial waste disposal services by transfer for land burial only: Bay Cities Transportation Co., San Francisco, Calif., Industrial Waste Disposal Corp., Houston, Texas; Laboratory for Electronics, Inc., Tracerlab Div., Waltham, Mass.; Long Island Nuclear Service Corp., Smithtown, N.Y.; Nuclear-Chem Disposal Corp., Long Island, N.Y.; Radiological Services Co., Inc., Long Island, N.Y.; and U.S. Nuclear Corp., Burbank, Calif.

In addition, seven organizations continue to be authorized to dispose of their own low-activity packaged radioactive waste at sea. The licensed organizations are: California Research Laboratory, Richmond, Calif.; National Institutes of Health, Bethesda, Md.; Socony Mobile Oil Co., Paulsboro, N.J.; U.S. Fish & Wildlife Service, Beaufort, N.C.; U.S. Naval Radiological Defense Lab., San Francisco, Calif.; University of Georgia, Sapelo Island, Ga.; and University of Hawaii, Honolulu, Hawaii.

Services (Category 8)

Although there are many service functions of importance to a developing atomic energy industry only a limited number are dependent on atomic energy activities for their development and well-being. Areas which have been studied this past year have included the following:

Film badges. A significant competitive film badge industry is now functioning. This industry is fully responsible for the handling of licensee film badges and is utilized in part by the AEC to meet certain of its film badge needs. At the end of the year a study was under way to determine the size of the film badge industry and the degree to which it may be dependent on Commission activities for its well-being.

Contaminated laundry. At a number of locations in the United States, privately owned laundries have been established to handle radioactivity contaminated articles. The AEC itself, at most of its locations, handles contaminated laundry from its own operations. In order to ascertain whether there is further potential for privately owned contaminated laundry facilities, a study was undertaken to show the costs of AEC processing of contaminated laundry at various sites and under varying conditions, particularly load. In parallel with this, the American Laundry Machinery Co. conducted studies intended to indicate the probably economic break points at which private laundries should be able to offer services attractive to certain AEC facilities now providing their own services. The results of these studies are expected to be useful to AEC facilities in reaching decisions on the most practical and economical means of handling contaminated laundry.

Shipments of Atomic Energy Products

Although a very significant part of today's private nuclear industry is vitally dependent upon the demands generated by the direct operations of AEC facilities and by AEC contracting with universities and private industry, a primary factor influencing the economic health of the industry has been the construction of large power reactors.

The absence of new construction starts of nuclear power plants is reflected in the most recent Bureau of Census report on shipments of selected key atomic energy products. For the first time, this indicator of industrial activity in nuclear work shows a decline.

The Bureau of Census issued the results of its annual survey on the value of atomic energy products shipped by manufacturers during 1961 on June 5, 1962. This was the fifth such survey made for the AEC. The data [21] shown in Tables 10 through 13 was obtained from

[21] The data for 1961 shown in Table 10 have been revised since the June publication.

282 establishments representing all known manufacturers of selected products specifically designed for use in nuclear applications. Excluded are construction expenditures, engineering and design costs, research and development expenditures, as well as shipments data for products used in atomic energy work which are not especially designed for nuclear applications.

Total Value Declines

During 1961, total shipments, including shipments to U.S. Government agencies, and exports of selected key atomic energy products manufactured in privately owned establishments totaled $270.4 million. This represents a marked decrease below the total value of shipments in 1960. In the first survey, for 1957, the total was $99.6 million; for 1958, it was $161.7 million; for 1959, it was $242.0 million; and for 1960, $285.6 million.[22]

The 1961 total included $12.5 million of nuclear reactors; $14.4 million of primary vessels and tanks; $15.1 million of heat exchangers and condensers; $20.4 million of pumps; $8.2 million of valves; $46.1 million of complete reactor fuel elements and control rods shipped directly for installation or use in a reactor; and $37.7 million of radiation, detection and monitoring devices. Also included in the figures are receipts for commercial irradiation services and receipts for conversion of enriched uranium which together totaled $15.5 million.

Products Covered

In addition, total dollar shipments contain data for the following products specifically designed for use in nuclear applications: Reactor moderators, coolants and reflectors; control rod drive mechanisms and components; accessory instrumentation for reactor control; pressurizers, components, and auxiliary equipment; fuel handling equipment; partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor; core structurals; hot laboratory equipment; shielding; radioactive isotopes (shipped from privately owned plants producing isotopes); radiation sources and other radioactive materials (produced from purchased isotopes); control and measuring devices containing radioactive isotopes; and specialized reactor components and equipment, not included elsewhere.

[22] See pp. 5–7, "Annual Report to Congress for 1961" for breakdown of 1957 and 1958 totals.

Net Order Survey

For 1961, respondents were asked to report net orders received for certain items on the survey. These net orders were defined to include (*a*) the sales value of orders accepted during the reporting period for products and services to be delivered at some future date; (*b*) the sales value of orders received during the reporting period for immediate delivery; (*c*) the net sales value of contract change documents which increase or decrease the sales value of the orders to which they are related when the parties concerned are in substantial agreement as to the amount involved. Included as orders were only those orders that are supported by binding legal documents, such as signed contracts, letters of awards, or letters of intent. In the case of letters of intent the full amount of sales value was included, if the parties concerned were in substantial agreement on this amount; otherwise, only the funds specifically authorized to be expended were included. Orders canceled during the year were excluded.

Net orders in 1961 included the following figures: Nuclear reactors, $7.8 million; primary vessels and tanks, $19.5 million; control rod drive mechanisms and components, $16.6 million; heat exchangers and condensers, $14.8 million; valves, $11.0 million; and complete reactor fuel elements and control rods shipped directly for use in a reactor, $33.5 million.

More complete descriptions of many of the line items of Table 11 and a definition of "net orders received" are included as Appendix 6.

Fuel Element Influence

Total in Table 10 for the last 3 years are heavily influenced by shipments of fuel elements which have accounted for between one-fourth and one-third of all shipments in recent years. An upswing in fuel element shipments is anticipated after 1961, based partly on increased orders for Naval cores (up by a factor of nearly two in fiscal year 1962 over fiscal 1961). Increases in AEC space and military reactor programs should also be reflected in increased shipments. Isotopes and radiation detection instruments have shown a steady increase over the last 5-year period of from slightly less than 15 percent to more than 20 percent annually. Sales abroad also appear to be taking a more favorable turn.

The total effect of all these factors would indicate a relatively steady level of operation for the industry as a whole for the next few years (a production plateau rather than a slump), with further substantial gains awaiting decisions to build large power reactors.

The distribution of shipments shown in Table 10 are given on a geographical basis in Table 12.

TABLE 10.—VALUE OF SHIPMENTS OF ATOMIC ENERGY PRODUCTS: 1959–61

(In thousands of dollars)

Product	1961			1960			1959		
	Total	U.S. Government agencies	Other including export	Total	U.S. Government agencies	Other including export	Total	U.S. Government agencies	Other including export
TOTAL	$270,419	XXX	XXX	*$287,570	XXX	XXX	$242,009	XXX	XXX
Nuclear reactors	12,541	$11,625	$916	12,389	(1)	(1)	7,497	(1)	(1)
Reactor components and equipment:									
Primary vessels and tanks	14,446	11,481	2,965	11,873	$10,064	$1,809	19,989	(1)	(1)
Control rod drive mechanisms and components	17,369	15,196	2,173	*16,688	*13,322	3,366	5,404	$4,766	$638
Accessory instrumentation for reactor control	16,482	10,871	5,611	*17,746	*11,515	*6,231	15,933	11,311	4,622
Heat exchangers and condensers	15,144	14,382	732	19,019	11,932	7,087	27,233	22,903	4,330
Pressurizers, components, and auxiliary equipment	1,252	1,078	174	2,034	(1)	(1)	3,620	(1)	(1)
Pumps	20,410	15,557	4,853	21,390	(1)	(1)	19,455	(1)	(1)
Valves	8,238	6,663	1,575	8,319	6,977	1,342	13,984	12,207	1,777
Fuel handling equipment	1,114	751	363	1,950	1,011	939	1,747	(1)	(1)
Complete reactor fuel elements and control rods shipped directly for installation or use in a reactor	46,155	40,185	5,970	81,165	73,909	7,256	54,845	(1)	(1)
Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor	18,892	12,172	6,720	14,335	11,116	3,219	11,773	(1)	(1)
Core structurals (barrels, cans, boxes, plates, etc., not included above)	7,180	7,076	104	*4,067	*3,516	551	5,255	3,258	1,727
Reactor moderators, coolants, and reflectors	4,201	3,485	716	3,278	1,669	1,609	4,684	2,068	2,616
Other specialized reactor components and equipment	7,024	4,022	3,002	*5,492	*3,556	*1,936			

Hot laboratory equipment	3,392	2,428	964	*4,158	*2,772	1,386	3,689	2,783	906
Shielding	6,636	4,113	2,523	*5,704	3,066	*2,638	1,797	1,313	484
Radiation detection and monitoring devices:									
Radiation survey monitoring and control devices	37,705	12,557	25,148	*31,156	*11,781	*19,375	10,527	5,829	4,698
Radiation counting equipment							15,486	2,825	12,661
Radioactive isotopes shipped from plants producing isotopes	1,688	185	1,503	*976	55	*921	459	58	401
Radiation sources and other radioactive materials produced from purchased isotopes	4,559	694	3,865	*4,158	652	*3,506	3,749	633	3,116
Control and measuring devices containing radioactive isotopes	10,500	1,291	9,209	*10,391	*2,860	*7,531	8,897	193	8,704
Commercial irradiation service	11,833	6,905	4,928						
Conversion of enriched uranium metal and compounds (excluding production or conversion of normal and depleted uranium)	3,688	1,164	2,524	11,282	5,923	5,359	5,986	2,638	3,348

[1] Withheld to avoid disclosing figures of individual companies.

*Revised.

TABLE 11.—VALUE OF NET ORDERS RECEIVED FOR SELECTED ATOMIC ENERGY PRODUCTS: 1961

(In thousands of dollars)

Product	Net orders received
Nuclear reactors	$7,761
Reactor components and equipment:	
Primary vessels and tanks	19,544
Control rod drive mechanisms and components	16,572
Heat exchangers and condensers	14,793
Pressurizers, components, and auxiliary equipment	3,754
Pumps	20,421
Valves	10,958
Fuel handling equipment	417
Complete reactor fuel elements and control rods shipped directly for installation or use in a reactor	33,544
Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor	7,893
Core structurals (barrels, cans, boxes, plates, etc., not included above)	1,782

TABLE 12.—VALUE OF SHIPMENTS OF SELECTED ATOMIC ENERGY PRODUCTS BY GEOGRAPHIC DIVISION AND STATE: 1960 AND 1961

(In thousands of dollars)

	1960	1961
UNITED STATES, TOTAL	$287,570	$270,419
NEW ENGLAND	69,362	38,319
Massachusetts	35,319	21,772
Rhode Island and Connecticut	34,043	16,547
MIDDLE ATLANTIC	89,067	81,798
New York	26,762	23,541
New Jersey	8,954	5,737
Pennsylvania	53,351	52,520
EAST NORTH CENTRAL	63,057	64,807
Ohio	40,126	37,572
Illinois	14,848	16,413
Indiana	3,906	5,467
Michigan	2,272	
Wisconsin	1,905	5,355
WEST NORTH CENTRAL	5,813	5,693
Minnesota, Iowa, Missouri, and Kansas	5,813	5,693
SOUTH ATLANTIC	10,445	15,053
Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida	10,445	15,053
EAST SOUTH CENTRAL	8,744	11,564
Kentucky and Tennessee	8,744	11,564
WEST SOUTH CENTRAL	299	161
Oklahoma and Texas	299	161
MOUNTAIN	2,406	2,572
Colorado and New Mexico	2,406	2,572
PACIFIC	38,377	50,452
Washington, Oregon, and California	38,377	50,452

CHANGES IN THE INDUSTRY

During the past year, the Westinghouse Testing Reactor at Waltz Mill, Pa., was closed down. Alco Products, Inc., Schenectady, N.Y., withdrew from the reactor building business, one of the reasons being the immediate future market did not look sufficiently attractive. The Makepeace Division of Englehard Industries at Plainsville, Mass., phased-out its fuel fabrication business due to a lack of sufficient work.

The Combustion Engineering Co., which had constructed an extensive nuclear facility at Windsor, Conn., released a portion of its facilities for other uses due to a lack of nuclear work. The Baker Division of Englehard Industries at Newark, N.J., withdrew from the recovery of unirradiated uranium scrap. The Curtiss-Wright

TABLE 13.—NUMBER OF COMPANIES AND ESTABLISHMENTS REPORTING SHIPMENTS OF SELECTED ATOMIC ENERGY PRODUCTS: 1960 AND 1961

Product	1960		1961	
	No. of companies	No. of establishments	No. of companies	No. of establishments
Nuclear reactors	12	12	9	9
Reactor components and equipment:				
Primary vessels and tanks	19	21	20	22
Control rod drive mechanisms and components	23	24	20	21
Accessory instrumentation for reactor control	28	37	27	34
Heat exchangers and condensers	19	20	16	21
Pressurizers, components, and auxiliary equipment	12	12	15	15
Pumps	15	15	15	15
Valves	25	28	24	29
Fuel handling equipment	14	14	12	12
Complete reactor fuel elements and control rods shipped directly for use in a reactor	11	13	11	12
Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor	15	15	17	17
Core structurals (barrels, cans, boxes, plates, etc. not included above)	14	14	13	13
Reactor moderators, coolants and reflectors	8	8	8	8
Other specialized reactor components and equipment	39	43	40	49
Hot laboratory equipment	20	25	15	20
Shielding	27	31	25	33
Radiation survey monitoring and analytical counting devices	47	83	49	84
Radioactive isotopes shipped from non-AEC plants producing isotopes	10	10	9	9
Radiation sources and other radioactive materials produced from purchased isotopes	20	27	18	26
Control and measuring devices containing radioactive isotopes	17	22	14	18
Conversion of enriched uranium metal and compounds (excluding production or conversion of normal and depleted uranium)	5	5	6	8
Commercial irradiation service	12	13	11	13

Corp. withdrew entirely from the nuclear field with the closing down of nuclear work at its Princeton (N.J.) Division.

On the other hand, outlook for the future of atomic power appears sufficiently bright to the Babcock & Wilcox Co. to justify a capital investment of $3.5 million in facilities for development work on power plants based on recycling uranium 233. Construction of these facilities started in early May 1962.

Nuclear activities of the Spencer Chemical Co. were transferred to Kerr-McGee (Kermac Nuclear Fuels Corporation). Production of uranium metal and oxide, and recovery of uranium from unirradiated scrap, formerly done in Spencer facilities at Pittsburg, Kans., are expected to be resumed in a Kerr-McGee plant in Oklahoma City, Okla.

The number of companies and establishments reporting shipments of selected atomic energy products under the Bureau of the Census survey noted above are shown in Table 13 for the years 1960 and 1961.

Development Work in Industrial Laboratories

Reactor development work assigned to private industrial organizations increased in the 1962 fiscal year over the 1961 fiscal year. This is a continuation of a trend over the past 5 years. Dollar expenditures with private industry have risen from $49.1 million in fiscal year 1958 to $123.9 million in fiscal year 1962. As a percentage of total reactor research and development expenditures, it has risen from 17 percent in fiscal year 1958 to more than 30 percent in fiscal

Table 14.—DISTRIBUTION OF RESEARCH AND DEVELOPMENT EXPENDITURES

(Fiscal years—Millions of dollars)

Type of organization	Reactor Development[a]		Physical Research		Biology & Medicine		Isotope Development		Peaceful Explosives		Total	
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
Industrial	$108.5	$123.9	$2.9	$1.8	$1.6	$1.3	$1.6	$2.2	------	------	$114.6	$129.2
AEC Laboratories	282.7	256.6	98.2	106.7	32.4	37.0	1.1	1.6	$7.0	$8.9	421.4	410.8
Universities	2.9	3.1	41.4	45.5	10.7	13.1	0.3	0.6	------	------	55.3	62.3
Other nonprofit	2.9	3.8	3.3	3.1	2.6	3.7	0.5	0.5	------	------	9.3	11.1
Other Government	3.3	9.3	4.9	1.6	2.9	3.2	0.2	0.2	------	------	11.3	14.3
Total[b]	400.3	396.7	150.7	158.7	50.2	58.3	3.7	5.1	7.0	8.9	611.9	627.7

[a] Data for reactor development are exclusive of certain equipment costs which were included in similar data shown in prior years' reports and figures for 1961 have been revised accordingly.

[b] These totals do not agree exactly with totals shown in the Annual Financial Report, Appendix 16. Depreciation on Commission-owned facilities and cost of special nuclear material consumed are not included here but are included in the Annual Financial Report. Also, this table includes some estimates of expenditures based on contract commitments.

year 1962. The distribution of these funds for the past 2 years is shown in Table 14 together with the distribution of other research and development funds associated primarily with peaceful uses of atomic energy.

GENERAL ACTIONS AND ACTIVITIES

Saline Water Conversion Program

The Atomic Energy Commission, during March, agreed to a request of the Department of the Interior for participation by the Commission's Oak Ridge National Laboratory (ORNL) in basic research phases of the Department's saline water conversion program. The studies involve the chemical properties of water and the technology of materials in aqueous solution.

This new research endeavor is made possible by the provisions of the Anderson-Aspinall Act (Public Law No. 87–295), approved by President Kennedy on September 22, 1961, which authorized expansion in the basic research activities of the Office of Saline Water (OSW).

Research extension. The AEC was requested to participate in the program because the research activities at ORNL are intimately related to OSW efforts and are logical extensions of current Oak Ridge research. Scientists at ORNL have long-term experience in chemical processing research, purification, and decontamination where the quantities of materials dissolved in water are routinely reduced to levels much lower than those required in the conversion of sea water to potable water.

This experience has grown out of the laboratory's concern with the purification of uranium before it goes into reactors, the processing of dissolved fission products, and of radioactive waste solutions.

In the past the efforts of the AEC National Laboratories have been directed exclusively to the development, use, and control of atomic energy. However, in a 1960 special report to the Joint Committee on Atomic Energy regarding "The Future Role of the AEC Laboratories" the Commission recognized "that the strong capabilities of the laboratories are not the exclusive resources of the atomic energy field; they are held in trust for the nation as a whole." The report further noted that "urgent work for other Federal agencies on matters of national concern will be accommodated in the laboratory when their skills are needed."

Employee Security Clearance Rules Changed

On May 5, 1962, the Commission revised its personnel security regulations to permit AEC employees or applicants for AEC employment to confront and cross-examine in security clearance proceedings persons who have made adverse statements against them. Included are provisions for limited exceptions to this general rule.

By virtue of this revision, the Commission has established for the first time a procedure whereby Federal employees and applicants for Federal employment are given such a right. Contractor employees and applicants have had the right of confrontation and cross-examination for some time, as a result of the Supreme Court decision of 1959 in *Greene* v. *McElroy*.

In the past, the AEC applied one set of procedural rules to such administrative hearings when they involved employees and applicants of AEC contractors, and another set of rules when they involved AEC employees or applicants. In the future, the same rules will apply to employees and applicants of both AEC and its contractors.

Exceptions to the right of confrontation are covered in Section 10.27(m) (1) and (2) of the revised Part 10, Title 10 of the Code of Federal Regulations, as follows:

> "(m) The individual shall be afforded an opportunity to cross-examine persons who have made oral or written statements adverse to the individual relating to a controverted issue except that any such statement may be received and considered by the Board without affording such opportunity in either of the following circumstances: (1) The head of the department supplying the statement certifies that the person who furnished the information is a confidential informant who has been engaged in obtaining intelligence information for the Government and that disclosure of his identity would be substantially harmful to the national interest; (2) The Commission or its special designee for that particular purpose has preliminarily determined, after considering information furnished by the investigative agency as to the reliability of the person and the accuracy of the statement concerned, that the statement concerned appears to be reliable and material, and the Commission or such special designee has determined that failure of the Board to receive and consider such statement would, in view of the access to Restricted Data or defense information sought, be substantially harmful to the national security and that the person who furnished the information cannot appear to testify (i) due to death, severe illness, or similar cause, in which case the identity of the person and the information to be considered shall be made available to the

individual, or (ii) due to some other cause determined by the Commission to be good and sufficient."

In instances where the individual is not accorded opportunity to cross-examine, he will be given a summary of the information in as much detail as the national security permits, and consideration will be given to the fact that the individual did not have an opportunity to cross-examine informants. When there are such exceptions, only the Commission has the authority to deny clearance.

Labor-Management Advisory Committee Formed

On March 30, the Commission announced establishment of a Labor-Management Advisory Committee of representatives of organized labor and of employers in the civilian atomic energy industry. Purpose of the advisory committee is to bring together representatives of organized labor and management to discuss general problems, procedures, and requirements in connection with the radiological aspects of industrial safety. Members of the Commission's technical staff will be available to the committee for consultation so that all radiological aspects of industrial safety will be carefully explored. The committee will not concern itself with matters of collective bargaining. (Names of members of the committee are given in the "Industrial Relations" section of Part Four of this report.)

Contractor Participation in Foreign Exchanges

The Atomic Energy Commission, on July 19, amended its regulations to expand the general authorization for participation in unclassified discussions and exchanges of unclassified information involving representatives of other countries and AEC contractors. Such an authorization from AEC for these activities involving representatives of foreign countries is required under the Atomic Energy Act where the activities could be construed to be directly or indirectly engaging in production of special nuclear (fissionable) material abroad.

In the past the Commission's general authorization has been limited to unclassified activities not involving countries designated by the U.S. Department of Commerce as *Subgroup A* countries. In general, Subgroup A countries are those which are members of the Sino-Soviet bloc.

Advantages. In recent years the Commission on numerous occasions has had to consider, and has uniformly granted, specific authorizations for participation in unclassified international conferences,

meetings of scientific groups, or U.S. State Department-approved exchange programs that may include Sino-Soviet bloc representatives. The subject matter in each instance has been unclassified and the information generated is published or can be obtained readily. At the same time, the relationship of participation by persons under the jurisdiction of the United States in these activities to the production of special nuclear material abroad has been remote—although it could not be said with legal certainty that their participation was permitted under the Atomic Energy Act without Commission authorization—and the advantages to the United States arising out of these activities have seemed positive and clear.

Authorized activities. For the above reasons, and to avoid the need for special authorization in such cases in the future, the Commission has authorized participation, without advance Commission approval, in the following unclassified activities even though such participation might conceivably be construed as engaging indirectly in the production of special nuclear material outside the United States:

1. Unclassified meetings or conferences sponsored by educational institutions, laboratories, or scientific or technical organizations and attended by nationals or representatives of Subgroup A countries.
2. Unclassified international conferences attended by nationals or representatives of Subgroup A countries.
3. Exchange programs approved by the Department of State.

At the same time, the Commission amended Part 110 of its regulations to add Poland and Cuba to the list of countries where the general authorization—other than for the specific activities listed above—is *not* applicable. This is consistent with the restrictions of the Department of Commerce on export of technical data.

Community Support

The remote locations of some of the major facilities of the nation's atomic energy program led to development, during World War II, of Government-financed communities to house personnel working at the facility. Prior to 1962, two such communities—Richland, Wash., and Oak Ridge, Tenn.—had attained independent municipality status with the aid of the Atomic Energy Commission. During 1962, the Commission started action to convert Los Alamos, N. Mex., to an independent city, and initiated a study that may lead to the development of a community to house workers for the Nevada Test Site, if no other solution to the recruitment and staffing problem can be found. Additionally, the Commission made a study of how it could cooperate in furthering the future industrial growth of communities adjacent to its major facilities.



Before and After. When the AEC, in 1957, began selling its property in Richland, Wash., such Government-built two-story duplexes as shown in photo *above,* were put on the market. Photo, *below,* shows how such a duplex has been attractively remodeled by its new private owner. From 1957 to 1961 inclusive, Richland building permits totaled $15,800,000 for alterations, improvements, and new construction. For the first nine months of 1962, they totaled $4,150,000, exclusive of high school and municipal construction. The city, with the assistance of the AEC, has undertaken a program to make its economic stability less dependent upon operations at the Commission's big Hanford production center. In 1960, only a year after it had become an independent municipality, Richland was designated an "All American City" by a national magazine.



RICHLAND-OAK RIDGE COOPERATION

During November, the Commission adopted a policy of cooperation in the industrial development efforts of communities in which AEC activities constitute the major economic force, such as Richland, Wash., and Oak Ridge, Tenn.

The formal statement of policy is:

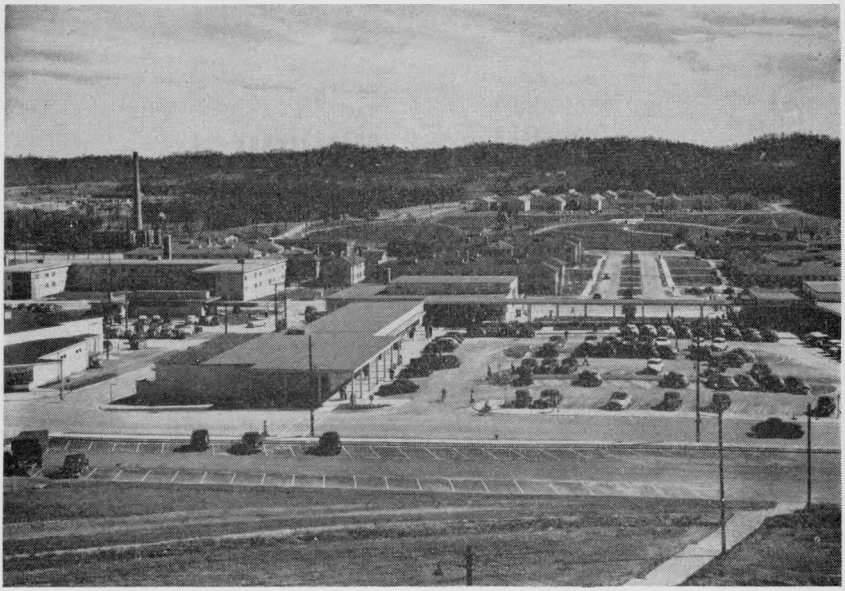
> "It is AEC policy to extend reasonable cooperation to the economic development efforts of communities in which AEC activities constitute the major economic force. In the interest of efficient performance of its programs, the AEC will cooperate in broadly supported community activities directed toward the maintenance of a reasonably stable and healthy economic environment in the community. Such cooperation will not be a substitute for community leadership and initiative, nor intrude in the management of local affairs by the elected representatives of the people."

The policy was established on the recommendation of a special study group which formulated its recommendations after visits to Oak Ridge and Richland where problems and suggestions were discussed with local representatives. The group also had numerous discussions with representatives of other interested Federal agencies.

Actions planned. In addition to recommending the general policy, the study group recommended a number of implementing actions at Oak Ridge and Richland.

Some of the actions planned by the Commission concern cooperation in community and regional land-use planning, including making land available to the communities for industrial use; cooperation with community efforts to obtain institutions of higher education and to increase the tourist industry, and cooperation with community efforts to attract and secure new industries. This includes participation in surveys of labor skills, making available unclassified technological data and information concerning estimated AEC procurement and service requirements and, where compatible with AEC operations and program requirements, considering requests from industry for particular services or for making land, facilities and equipment available for use by industry.

Reason for study. The study was initiated as a result of consideration by the Commission of a proposal by the Exo-Met Co. of Richland to lease or buy certain metal fabrication facilities on the Hanford Plant reservation. Although the proposal was denied, the study was undertaken to determine the ways in which the AEC can facilitate the efforts of communities such as Richland and Oak Ridge to attract industries which can provide commercial products or services without being completely dependent upon AEC operations.



Old and New. Photo *above*, made some 15 years ago, shows the Oak Ridge community's Jackson Square business section with the old Manhattan Engineer District headquarters in the background. This small shopping center is now privately owned and still in operation. The photo *below* shows the recently completed "Downtown" shopping center at Oak Ridge. Built as a Government-housing project during World War II, Oak Ridge, Tenn., became an independent municipality in 1959, when the Commission sold its property and buildings to private owners and transferred its municipal functions to a newly formed local government. In addition to financial aid, the AEC is cooperating with the Oak Ridge civic leaders in making the community attractive to new industry and tourists so that its economic base will be less dependent upon Oak Ridge National Laboratory operations.



First step. As the first step in its community cooperation plan, the Commission has changed the name of the Hanford Operations Office to Richland Operations Office. The name change, which was effective January 1, 1963, was originally suggested by citizens of Richland and was included in the study group's recommendations on ways the AEC might cooperate in industrial development efforts of communities such as Richland and Oak Ridge. It is believed that this change will help identify the operations office with the community thereby advertising the city and possibly assisting it in attracting industry. The operations office administers the Commission's Hanford plant which is contractor-operated by the General Electric Co.

COMMUNITY TRANSFER

As of November 30, 1962, a total of $62,598,000 had been returned to the Government through sales of property in Oak Ridge—$26,887,000—and Richland—$35,611,000, including $2,009,500 from sale of the community telephone system—as a result of the Atomic Energy Community Act of 1955 which authorized sale of the property and transfer of the municipal installations of the two Government-built cities.

Since ground was broken in 1943 at both townsites, the total cost to the Government for the Oak Ridge Community facilities was $126.8 million, and for Richland it was $111.5 million. Since that time depreciation, demolitions, transfers, and sales have virtually eliminated the Government's investment in these two communities.

Property Sales

The first offering of homes for sale at Oak Ridge was made on September 7, 1956, and in Richland on June 12, 1957. By November 30, 1962, all property in Oak Ridge, and all except 52 commercial parcels in Richland had been sold. All properties offered for sale were placed under the jurisdiction of the Housing and Home Finance Administration (HHFA) which made the following dispositions:

TOTAL PROPERTY SALES AS OF NOVEMBER 30, 1962

	Oak Ridge		Richland	
	Units offered	Percent sold	Units offered	Percent sold
Single and duplex houses	4,360	100	4,806	100
Apartments (4 or more family units)	257	100	17	100
Vacant lots and land parcels	1,761	100	292	100
Commercial properties	115	100	234	78
Nonprofit	33	100	13	100

Financial Assistance

Both Oak Ridge and Richland became incorporated cities during 1959, and during 1960 the AEC completed the transfer of all municipal functions to the cities. Under the Atomic Energy Community Act of 1955, the Commission is obligated to provide "just and reasonable" financial assistance to the cities for 10 years after the transfer of the municipal functions.

At Oak Ridge, this financial assistance payment is made directly to the city, and includes support of the school system which is an arm of the city government. During fiscal year 1962, the payment amounted to $1,238,740 which was less than the FY 1961 payment by $1,105,111 on account of the receipt of State and county school funds by the city for the first time in FY 1962.

For Richland, the payment is made in two parts. One part to the school district is in amounts calculated on a basis consistent with the formula used by the U.S. Department of Health, Education, and Welfare in providing assistance to "Federally impacted" schools throughout the country. The other part is paid to the city government, in amounts periodically negotiated with city officials as the need arises. During 1962, $677,000 was provided the school district and $347,000 to the city government. No assistance payments have been made to Kadlec Methodist Hospital since January 1961, at which time a total of $393,000 had been paid to the hospital under the provisions of the Community Act of 1955. It is not expected that any further assistance payments will be needed by the hospital.

LOS ALAMOS COMMUNITY

On September 28, 1962, the President signed legislation amending the Atomic Energy Community Act of 1955 to authorize termination of AEC ownership and management of the community of Los Alamos, N. Mex. The amendment provides for the sale, under a system of priorities, of residential and commercial property, the donation or sale of utility systems, and the transfer of municipal functions at Los Alamos.

Authorization

The legislation also authorizes $8.7 million in construction projects, *e.g.*, addition of schools, development of Barranca Mesa for private homes, in connection with the disposal of the community and further provides that AEC will make "just and reasonable" assistance payments to the local government or other qualified entity for a period of 10 years following transfer of municipal facilities. In view of the

magnitude of pre-disposal activities such as zoning and platting the community, classifying and appraising the property, it is anticipated that property sales will not start for about two years.

The Commission's proposal for legislative action followed its determination that the Government can terminate its management of the Los Alamos community without impeding the mission of the Commission's Los Alamos Scientific Laboratory.

While Los Alamos residents already have a degree of self-government, transfer of housing to private ownership and municipal facilities to the local government or other local entity will give residents full responsibility for managing their own community affairs. The Federal property involved has a current book value of about $55 million.

Many Apartment-type Buildings

Approximately two-thirds of Los Alamos housing units are duplexes or buildings containing a larger number of units. Where duplexes and larger residential buildings can be divided for the purposes of sale, each unit in the building will be offered for sale separately. In determining whether such buildings can be divided for purposes of sale, consideration will be given to physical layout as well as insurability of mortgages on the separate units. Duplexes which cannot be divided will be offered first to senior tenants. Sale of the larger buildings which cannot be divided will be by competitive bid or sold to cooperatives composed of project-connected personnel. The proposed legislation authorizes the AEC to retain for its own use certain property within the community.

The Atomic Energy Community Act of 1955 provides for certain percentage reductions from appraised prices to priority holders in setting the sale price for residential property. These reductions will be continued at Los Alamos.

The Act also includes provisions for annual AEC assistance payments to help support school and municipal operations. The legislation does not make any changes to these provisions.

Actual sales and financing functions will be handled by the Housing and Home Finance Agency as was the case at Oak Ridge, Tenn., and Richland, Wash.

Built in 1942

Prior to 1943, a few settlers had farmed or ranched in the general Los Alamos area and on the present townsite there was a Los Alamos Ranch School for boys. The town occupies several finger mesas of

the Pajarito Plateau, on an eastern shelf of the Jemez Mountains at an altitude of 7,400 feet.

In late 1942, the Manhattan Engineer District selected Los Alamos as a site for a laboratory to develop atomic weapons. The Los Alamos Scientific Laboratory was established in April 1943, operated for the Government then as now by the University of California. In 1947, after transfer of the facility to the Atomic Energy Commission, the question of abandoning the location was considered and the determination was to make Los Alamos a permanent facility. Book value of the Government's facilities there now approximates $230 million.

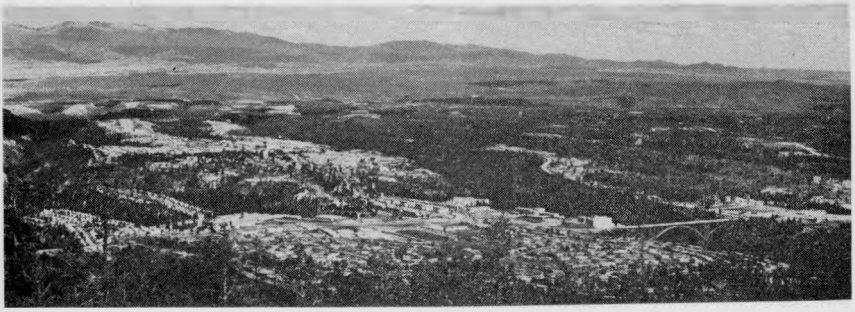
Los Alamos County

The State, in 1949, established Los Alamos as a county and subsequently granted the county the powers of an incorporated municipality. The county has a board of commissioners which enacts municipal-type ordinances and levies and collects real and personal property taxes, although very little real property is now taxable as the Federal Government owns almost all realty. The AEC provides police and fire protection, but the police power of the federally employed policemen flows from a sheriff elected under State law. The county has an Assistant District Attorney and courts. Schools are operated by a school district also under State law.

The county, by contract with the AEC, operates several parks and playgrounds, and is currently negotiating to take over operation of the public library and a golf course.

Several Studies Made

Community disposal has been studied on various occasions. A Citizen's Los Alamos Charter Commission worked throughout 1948 preparing a plan for assumption of municipal responsibilities by residents. In the same year, an AEC consultant studied the matter. In 1952, the Commission's "Scurry Panel" analyzed the situations at the three AEC communities, recommending early disposal action for Oak Ridge and Richland but finding that special circumstances existed at Los Alamos and recommending against early disposal. For 6 months in 1960, the Los Alamos Planning Committee studied the problem and recommended that the AEC move toward disposal as soon as feasible. In late 1961, representatives of the Housing and Home Finance Agency reviewed the readiness of Los Alamos for disposal in light of the experience gained in the Richland and Oak Ridge disposal programs. Following this review, HHFA concluded in its report to AEC that a disposal program can be conducted successfully at Los Alamos.



Los Alamos Sale. During 1962, the Commission was authorized to dispose of the Los Alamos, N. Mex., community through sale of homes and commercial property and transfer to local control of municipal facilities and functions. Los Alamos, which houses most of the employees of the AEC's Los Alamos Scientific Laboratory, will be the third Government-built community to be given an independent status by the Commission. The first two were Oak Ridge, Tenn., and Richland, Wash. Photo *above* shows a major part of the Los Alamos community which is located on several fingers of the Pajarito Plateau some 30 air miles northwest of Santa Fe. Photo *below* shows a typical Los Alamos residential street. Approximately two-thirds of the community's housing, however, is in duplexes or apartment buildings.



Los Alamos county now has approximately 15,000 residents. About 1,800 other project employees reside elsewhere and commute to the laboratory.

Barranca Mesa Development

The program [23] for the development and sale of lots on Barranca Mesa for the construction of privately owned houses by Los Alamos Scientific Laboratory project-connected persons will be continued by the AEC. There are, in Barranca Mesa Subdivisions 1 and 2, a total of

[23] During 1957, the Commission approved a long-range, land-use plan for Los Alamos and, subject to availability of funds, authorized a start on developing the Barranca Mesa project, north of town, for building sites for privately owned homes. The initial project consisted of 72 lots.

206 lots. As of November 15, there were 131 houses completed; 56 houses were under construction, and the construction of houses on the majority of the remaining lots is in the planning stages.

Site improvements have been completed on 11 lots in Phase A, Barranca Mesa Subdivision No. 3, another 11 lots have been sold, and the construction of site improvements to make 39 additional lots available in this subdivision started in September 1962.

White Rock Development

As of November 15, the contractor—Noxon Construction Co. of Los Angeles, Calif.—undertaking the initial real estate development in the White Rock area near Los Alamos had completed 33 houses, 44 houses were under construction and the contractor reported 17 additional contracts for the construction of houses. This contract requires the development of at least 200 houses or lots by June 1963 for sale to Los Alamos project-connected persons. This project is another step in the direction of eliminating the housing shortage at Los Alamos.

Site Leasing

The leasing of unimproved building sites for the construction and operation of privately owned commerical facilities in Los Alamos is a continuing program. During the year, two more privately owned commercial buildings have been completed and business operations have started. Private commercial construction on additional sites is in the planning stages, or under way.

NEVADA TEST SITE

At the year's end, the Commission was considering the need for housing and related community facilities nearer the Nevada Test Site than Las Vegas. The need for such housing was emphasized by the substantial increase in employment projected for the Space Nuclear Propulsion programs (ROVER) at the Nuclear Rocket Development Station (NRDS) which is approximately 90 miles from Las Vegas. Currently, workers at the NRDS commute from 180 to 200 miles a day requiring up to 4 hours of travel time each day. In order to recruit and retain an adequate number of competent professional and technical personnel, the establishment of a community may be required if no other solution, such as fast transportation, appears feasible.

Capital Plant and Property Management

Construction Costs

As of December 31, 1962, the Nation's investment in atomic energy facilities was $7.5 billion before depreciation reserves.

Total plant acquisition and construction costs incurred by the Commission during fiscal year 1962 declined about 9 percent from the previous year to $278 million. The special nuclear materials program accounted for the largest single portion of the construction effort and, although the reactor development program declined somewhat from FY 1961, it still accounted for about one-third of the entire construction effort. There was also a sharp increase in the weapons program. Capital equipment costs for replacement or addition of equipment to existing plant (laboratory, hospital, and other types of equipment) reached a 7-year high of $140 million. The following table [24] shows capital costs incurred during the past seven years:

Fiscal year	*New plant construction*	*Capital equipment (not related to construction)*
	(In millions)	
1962	$278	$146
1961	308	125
1960	231	101
1959	212	87
1958	210	80
1957	260	57
1956	264	38

Records and Property Management

The Commission and its principal cost-type contractors destroyed more than 120,000 cubic feet of records having no further value during 1962. This quantity is equivalent to the contents of 20,000 four-drawer filing cabinets. Approximately 40 percent of total records holdings, having further reference value to the Government and its cost-type contractors, is housed in low-cost storage.

Continued emphasis on utilizing excess property available from other Federal agencies resulted in significant progress throughout AEC activities during the year. A total of about $18 million (acquisition cost) was utilized during fiscal year 1962. This was an increase of 50 percent over the $12 million utilized during fiscal year 1961.

[24] A more complete breakdown of these, and other figures will be found in the Commission's Annual Financial Report, Appendix 16.

New Divisions and Offices

During 1962, the Commission established two new divisions within its Headquarters and two field organizations, and abolished one field office.

Nuclear Education and Training

On March 1, the establishment of a Division of Nuclear Education and Training was announced for the purpose of consolidating and strengthening the Commission's activities in this field for graduate students, high school and college science teachers, and other professional personnel.

The new division will administer education and training programs in the nuclear sciences and engineering; the use of isotopes and radiation in the physical and engineering sciences; radiation biology for the life sciences; health physics; industrial medicine and industrial hygiene. These programs have previously been administered by the Coordinator of Nuclear Education and Training, the Division of Isotopes Development, and the Division of Biology and Medicine.

In addition to its responsibilities in program administration, the new division will be responsible for developing and maintaining commission-wide policies pertaining to nuclear education and training and for reviewing and coordinating all AEC education and training programs, including those administered by other offices and divisions of the Commission.

Division of Plans and Reports

The Commission undertook additional measures to enhance its planning, project control, and reporting functions through the formation of a Division of Plans and Reports on July 30. The new division consolidates activities previously performed by the Division of Plans with certain reporting functions previously done by the Division of Public Information and Office of the Controller.

Long-range plans, extending a minimum of 5 years, have been developed for a selected number of programs in key areas of interest to the Commission.

The Federal Council on Science and Technology was provided information about the Commission's research and development levels projected to 1970.

As part of its cooperative efforts with other Federal agencies, the Division of Plans and Reports participated in the activities of the PERT (Program Evaluation and Review Technique) Coordinat-

ing Group. The group is an intergovernmental agency committee established to foster uniformity of terms and reporting practices by Government agencies using the management analysis technique known as PERT, and to extend its use wherever appropriate. In this connection, the AEC has contributed to a PERT Management Guide being prepared by the PERT Coordinating Group for use throughout Government. The AEC had a number of persons trained, at institutes established by the various Armed Forces, to give PERT instruction within the Commission structure on the PERT system.

Industry doing business with AEC will be encouraged to use management techniques such as PERT and PERT/cost wherever appropriate.

New Nevada Operations Office

The Commission's Office of Field Operations at Las Vegas, has been changed to the Nevada Operations Office and assigned the responsibility for the management of the Nevada Test Site.

Under the change, which became effective March 6, the Las Vegas Office will be expanded and will report directly to the Office of the General Manager in Washington rather than to the Commission's Albuquerque Operations Office as did the Office of Field Operations.

Direct, onsite management required by the expanded level of activity at the Nevada Test Site will be provided by the expansion and change in status of the Las Vegas office.

The need for this change stems from the increasing operations at the test site, resulting from testing connected with the development of nuclear propulsion for rockets (Project Rover) and the construction of new facilities for the National Aeronautics and Space Administration's portion of that program, together with the current underground testing of nuclear weapons.

Space Nuclear Propulsion Office-Nevada Extension

On October 5, 1962, the joint Space Nuclear Propulsion Office of the Atomic Energy Commission and the National Aeronautics and Space Administration established a Nevada extension which will have charge of the construction and operation of the Nuclear Rocket Development Station. The station will be the national site for testing of nuclear rockets under the Nerva Program and is located on the Commission's Nevada Test Site reservation. The Space Nuclear Propulsion Office-Nevada (SNPO–N) is located in Las Vegas.

Lockland Area Office

Effective June 30, the Commission's Lockland, Ohio, Area Office was abolished. The office had previously been involved in activities associated with the Aircraft Nuclear Propulsion (ANP) program which had been terminated during 1961.

Access Permits

The Commission's Access Permit Program permits persons, after appropriate security approval and access authorizations, to obtain access to restricted data which are of value to private business and research in the development of peaceful uses of atomic energy.

New Access Areas

Seven additional categories of classified information were made available to Access Permit holders during the past year.

The Commission had amended its regulations (10 CFR Part 25) in late December 1961 to add the following categories to the Access Permit Program: C–90, Nuclear Reactors for Ram-Jet Propulsion; C–91, Nuclear Reactors for Rocket Propulsion; C–92a, Systems for Nuclear Auxiliary Power (SNAP)—Isotopic; C–92b, Systems for Nuclear Auxiliary Power (SNAP)—Reactor; C–93a, Advanced Concepts for Future Application—Reactor Experiments; and C–93b, Advanced Concepts for Future Application—Conversion Devices.

During 1962, the Commission amended Part 25 to simplify the requirements for obtaining classified data on the PLUTO (C–90) and SNAP (C–92 a and b) programs, as well as information on advanced concepts of reactors (C–93 a and b). Project PLUTO is designed to demonstrate the feasibility of a nuclear ramjet engine for use in strategic missiles. SNAP is the Commission's program of Systems for Nuclear Auxiliary Power, employing both radioisotopes and reactors as a power source in space and at remote locations on land and in the sea. Access was also provided to new classified information in category C–94, Military Compact Reactor, by this amendment.

Certain requirements for the safeguarding and transmission of Restricted Data received under an Access Permit were revised by amendment in 1962 of 10 CFR Part 95. This amendment requires, for the first time, an Access Permittee yearend report which will provide the AEC with information on the use of Permits and the continuing need for the program.

Permit Distributions

As of November 30, 1962, there were 700 Access Permits in effect, as compared with 835 in 1961.

The distribution of Access Permits by geographic area, industry, and field of interest is given in Tables 16 thru 18, below.

TABLE 15.—NUMBER OF PERMITTEES HAVING ACCESS TO SECRET RESTRICTED DATA BY CATEGORIES

	Nov. 30, 1961	*Nov. 30, 1962*
Isotope Separation—Gas Centrifuge Method (C–24)	1	4
Nuclear Technology (C–44)	599	502
Plutonium Production (C–65)	10	10
Nuclear Reactors for Ram-Jet Propulsion (C–90)	(*)	31
Nuclear Reactors for Rocket Propulsion (C–91)	(*)	14
Systems for Nuclear Auxiliary Power (SNAP)—Isotopic Program (C–92a)	(*)	38
Systems for Nuclear Auxiliary Power (SNAP)—Reactor Program (C–92b)	(*)	36
Advanced Concepts for Future Application—Reactor Experiments (C–93a)	(*)	43
Advanced Concepts for Future Application—Conversion Devices (C–93b)	(*)	37
Military Compact Reactor (MCR) (C–94)	(**)	3

* Added to access permit program in December 1961.

** Added to access permit program in August 1962.

NOTE: As of Nov. 30, 1962, 329 permittees had 500 employees or less, while 371 had over 500 employees. As of Nov. 30, 1961, permittees with 500 or less employees numbered 415, while 420 had over 500 employees.

TABLE 16.—ACCESS PERMIT HOLDERS BY GEOGRAPHIC AREAS *

	Nov. 30, 1961	*Nov. 30, 1962*
New England	83	69
Middle Atlantic	318	286
East North Central	146	102
West North Central	42	24
South Atlantic	83	78
East South Central	19	18
West South Central	36	35
Mountain	17	11
Pacific	88	74
Hawaii, Alaska and Puerto Rico	3	3
Total	835	700

* Standard Department of Commerce Areas.

TABLE 17.—ACCESS PERMIT HOLDERS BY PRINCIPAL FIELDS OF INTEREST

	Nov. 30, 1961	*Nov. 30, 1962*
Batteries (Nuclear)	0	0
Chemical Processing and Equipment	36	33
Components (except Reactor Components)	38	29
Consultants	102	82
Controlled Thermonuclear Field	17	13
Design and Construction of Atomic Energy Facilities	53	40
Electronic Systems	8	9
Fuel Element Fabrication	21	18
General Nuclear Research and Development	46	48
Information Services	27	17
Instruments	49	37
Insurance Evaluation	63	61
Investment and Banking	5	4
Isotope Production and Utilization	44	37
Legal Assistance and Accounting	24	24
Machinery	10	11
Ore Refining and Production of Feed Materials	34	25
Radiation Hazards and Effects	31	26
Radioactive Waste	23	19
Reactor-Central Station	130	96
Reactor-Components	30	21
Reactor-Heating	4	4
Reactor-Other	19	16
Reactor-Propulsion	35	28
Reactor-Research	11	7
Shield Materials	11	9
Special Materials	60	48
Surveys for Potential Use or Need	9	5
Training and Education	9	8
Transportation and Storage	3	2
Weapons and Components	0	2
Others (not elsewhere classifiable)	6	5
Total	958	784

NOTE: These figures include permit holders with more than one field of interest, resulting in a total greater than the number of permittees.

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TABLE 18.—BUSINESS OR OCCUPATION OF ACCESS PERMIT HOLDERS

	Nov. 30, 1961	*Nov. 30, 1962*
Aircraft and/or Components	30	25
Beverage Industry	1	1
Chemical-General	50	40
Chemical-Pharmaceutical	3	3
Chemical-Processing Equipment	11	13
Coal Industry	2	3
Communications	0	0
Consultants	51	40
Educational Institutions	19	16
Electronic Industry	25	19
Engineering-Construction	27	21
Engineering-Consulting	55	50
Engineering-Design	28	26
Federal, State and City Governments or Departments	32	24
Financial Organizations	5	4
Food Companies	1	1
Information Services	11	11
Instrument Manufacturer	40	30
Insurance Companies	61	57
Lawyers and Public Accountants	25	25
Machinery-General	22	21
Machinery-Special	16	15
Metal Products Manufacture	83	00
Mining and Refining	25	23
Motor Vehicles and/or Components	4	3
Paper and Pulp Companies	1	0
Petroleum and Petroleum Products	13	14
Printing and Publishing	3	2
Professors, Teachers, and Scientists	16	11
Railroads and Railway Equipment	10	8
Research-General	35	39
Research-Medical	3	5
Rubber and Rubber Products	3	2
Scrap and Waste Disposal	4	4
Shipbuilding and/or Components	16	13
Special Carriers and Warehousing	2	1
Stone, Clay, and Glass Products	12	9
Tobacco and Tobacco Products	0	0
Unions, Trade Associations, Chambers of Commerce, and Manufacturers' Representatives	11	7
Utilities	112	84
Weapons, Explosives, and Propellants	3	3
Others (not elsewhere classifiable)	7	3
Total [a]	878	736

[a] Some permittees have been classified in more than one category.

Patent Matters

Patents Available

During 1962, four separate listings of abstracts on 209 Commission-owned U.S. patents available for licensing were issued.[25] These abstracts were distributed to 945 individuals, corporations, and organizations. The Commission's Office of the Assistant General Counsel for Patents received over 165 specific inquiries pertaining to these releases, aside from granting 60 nonexclusive licenses during the year on Commission-owned U.S. Patents. At present a total of 925 nonexclusive licenses has been issued on some 400 of the 2,974 Commission-owned patents. In addition, 492 nonexclusive licenses have been retained by contractors. Contractors have retained exclusive licenses in fields other than atomic energy in 242 patents. In 293 instances, the title and rights in the patents are vested in the contractors, subject to a nonexclusive license in the Government for governmental purposes.

The U.S. Patent Office has issued 247 patents to the Commission since November 30, 1961. As a result, the portfolio of Commission-owned U.S. patents available for licensing numbers 2,974 patents in addition to the 374 foreign patents issued during this period.[26] The total of the foreign Commission-owned patents is 1,107, of which 191 are British, 213 are Belgian, 200 are Canadian, 207 are French, 46 are German, 18 are Japanese, and the balance are patents issued by 14 other countries.

Revised Background Patent Rights

On June 29, 1962, revised instructions with respect to the employment of background patent rights provisions in Commission contracts were issued in the form of an Immediate Action Directive to the Commission's contracting personnel. The new instructions set forth the criteria for such provisions, with an appeal to the General Manager of the Commission in cases where contractors deem that no background provision should be incorporated.

Patent Settlements and Litigated Matters

The Commission settled Edgerton, Germeshausen & Grier, Inc., patent matters for $200,000 upon receipt of a release for past infringement by AEC with respect to some 70 patents and receipt of a non-

[25] Listings published as Commission press releases numbered: IN–305, March 16; IN–333, July 5; IN–356, August 17; IN–378, October 8 and IN–396, December 12; copies available from Division of Public Information, Atomic Energy Commission, Washington 25, D.C.

[26] Listings of the foreign abstracts made available during 1962 were published as Commission press releases, numbered: IN–287, January 5 (German patents); IN–291, January 23 (British); IN–296, February 9 (Canadian); IN–341, July 13 (Belgian); IN–344, July 17 (French); IN–364, September 4 (British); copies available from Division of Public Information.

exclusive license for Commission and Atomic Energy uses of 49 unexpired U.S. patents.

The Patent Compensation Board rendered decisions [27] on the following ten dockets: Docket No. 16—N. V. Philips Gloeilampenfabrieken; Docket No. 18—The Commissariat a L'Energie Atomique; Docket No. 25—William A. Fletcher; Docket No. 26—Frank E. Dudley; and Docket No. 27—Herbert L. Anderson; and Docket Nos. 29 thru 33—Alga M. Tabor. The Commission denied appeals in the Philips and Anderson cases, and appeals have been taken to the U.S. Court of Appeals, District of Columbia, in Philips' Docket No. 16, and to the U.S. Court of Appeals for the Seventh Circuit in the Anderson Docket No. 27. In Docket No. 18, the Commission, upon petition, remanded the case to the Board for action on a Petition for Reconsideration that was filed by the Applicants with the Patent Compensation Board.

UKAEA Agreement

Agreements with respect to the rights in inventions made by personnel exchanged between the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority and their respective contractors were consummated on August 7, 1962. Under the agreements, the United States acquires the rights in the United States, subject to limited license rights to the UKAEA, and the United Kingdom acquires rights in the United Kingdom, subject to limited license rights to the USAEC. The rights in third countries are vested in the United States or the United Kingdom, depending upon where the invention is made, and subject to the other party having non-exclusive license rights for governmental purposes, and for purposes of treaty or agreement with such third country together with license rights, with the right to grant sublicenses, in the atomic energy field.

Euratom Exchange

Assurances have been exchanged with Euratom that the provisions of Article VII of the U.S.-Euratom Basic Agreement are applicable to inventions made by exchanged personnel. Thus, under Article VII the United States will acquire the rights in the United States, subject to limited rights in Euratom, and, vice versa, Euratom will acquire the rights in Euratom countries, subject to limited license rights of the U.S. Government in Euratom countries. The principal rights in third countries would be vested in the United States or Euratom, depending upon where the invention is made, but in all events the U.S. Govern-

[27] Copies of the Patent Compensation Board decisions may be obtained from the Office of the Assistant General Counsel for Patents, U.S. Atomic Energy Commission, Washington 25, D.C.

ment acquires limited license rights in any such inventions in third countries.

Private Atomic Energy Applications

The Patent Office, in the past year, reported 683 patent applications under Section 152 of the Atomic Energy Act of 1954, as amended, on inventions purportedly not made or conceived in the course of, or under, a Commission contract. The Commission filed 25 directives for acquisition of rights under the Atomic Energy Act, bringing the total directives filed under Section 152 since 1954 to 85. The Commission has acquired rights in 38 applications, and in 24 cases, after completing the investigation, the directives were withdrawn without the acquisition of any rights. At year's end, the remaining 23 cases were pending.

SCIENTIFIC AWARDS

Enrico Fermi Award

Dr. Edward Teller, internationally-known nuclear scientist, was named to receive the Commission's Enrico Fermi Award for 1962. Dr. Teller, the sixth scientist to be named for the Fermi Award, received a gold medal, a citation and $50,000 at a White House ceremony on December 3. The citation of Dr. Teller reads:

> "For contributions to chemical and nuclear physics, for his leadership in thermonuclear research, and for efforts to strengthen national security."

The Fermi Award is made on the recommendation of the Commission's General Advisory Committee, established by the Atomic Energy Act to advise the Commission on scientific and technical matters, and is approved by the President. The award is named in honor of the late Dr. Enrico Fermi, leader of the group of scientists who achieved the first self-sustained, controlled nuclear chain reaction on December 2, 1942.

Varied contributions. In a summary of Dr. Teller's scientific contributions on which the recommendation was based, the General Advisory Committee stated:

> "Dr. Teller is considered one of the most original, imaginative, and versatile scientists in the world today. His contributions to science extend from engineering and technology to physics and chemistry, to the most abstract theories in quantum mechanics.

There is a similarly wide range in the character of his contributions. Some form the foundations for major structures in scientific theory; some are illuminating flashes of insight which have helped to solve practical but often tantalizing puzzles."

Developed thermonuclear weapons. Even before the first atomic fission bomb was completed, the Hungarian-born scientist had formulated ideas on thermonuclear (fusion) devices and after the war he helped develop the principle that insured successful development of the thermonuclear weapons.

During World War II, Dr. Teller served as a physicist with the Manhattan Engineer District at the University of Chicago and the Los Alamos Scientific Laboratory.

Dr. Teller was an assistant director of the Los Alamos Scientific Laboratory from 1949 to 1952. He has been associate director of the E. O. Lawrence Radiation Laboratory at Berkeley, Calif., since 1954 and from April, 1958, to July, 1960, was director of the Livermore Laboratory. He is also professor-at-large in the University of California. He and his family reside in Berkeley, Calif.

Previous winners. Dr. Fermi was the first to receive an award under the Atomic Energy Act of 1954 and the Commission decided that subsequent awards should bear the name of the Italian scientist. The five previous Fermi Award winners, their citations and the years in which they were honored:

1956—The late Dr. JOHN VON NEUMANN, noted scientist and mathematician and member of the Atomic Energy Commission, for his contributions to the theory, design and construction of fast computers and to the role of computers in the control and use of atomic energy.

1957—The late Dr. ERNEST O. LAWRENCE, Director of the Radiation Laboratory, University of California, which bears his name, "for his invention and development of the cyclotron and for his many other contributions in nuclear physics and atomic energy."

1958—Dr. EUGENE WIGNER, Professor of Mathematical Physics, Princeton University, for "contributions to nuclear and theoretical physics, to nuclear reactor development and to practical applications of atomic energy."

1959—Dr. GLENN T. SEABORG, Chairman of the Commission, who was Chancellor of the University of California when he received the award "for discoveries of plutonium and several additional elements and for leadership in the development of nuclear chemistry and atomic energy."

1960—No award was made.



Lawrence Award Recipients. Five outstanding nuclear scientists shared in the Commission's 1962 E. O. Lawrence Award, each receiving a citation, a medal, and $5,000 at the April 23 ceremony. The award winners are shown above, *left to right:* Dr. Herbert Goldstein, Professor of Nuclear Engineering, Columbia University, New York City; Dr. Andrew A. Benson, Department of Biophysics and Nuclear Medicine, Laboratory of Nuclear Medicine and Radiation Biology, University of California at Los Angeles; Dr. Herbert F. York, Chancellor, University of California at San Diego (La Jolla, Calif.); Dr. Anthony L. Turkevich, Professor, Department of Chemistry, University of Chicago; and Dr. Richard P. Feynman, Professor, Theoretical Physics, California Institute of Technology, Pasadena, Calif.

1961—Dr. Hans A. Bethe, Professor of Physics at Cornell University "for contributions to nuclear and theoretical physics, to peaceful uses of atomic energy and to the security of the United States."

E. O. Lawrence Award

Five U.S. scientists were chosen to receive the Commission's Ernest Orlando Lawrence Memorial Award for 1962. The Commission made the awards upon the recommendation of its General Advisory Committee and with the approval of the President. Each recipient received a citation, a medal, and $5,000 at an April 23 ceremony at the National Science Foundation Auditorium in Washington, D.C.

Award Winners

The five scientists were:

Dr. Andrew A. Benson, Department of Biophysics and Nuclear Medicine, Laboratory of Nuclear Medicine and Radiation Biology, University of California at Los Angeles: for outstanding biochemistry

contributions to elucidation of the carbon reduction cycle in photosynthesis through his development of double labeling techniques employing carbon 14, tritium, and phosphorus 32.

Dr. Richard P. Feynman, Professor, Theoretical Physics, California Institute of Technology, Pasadena: for important contributions to quantum field theory and particle physics, for invention of Feynman diagrams, and for broad scientific interests and knowledge.

Dr. Herbert Goldstein, Professor of Nuclear Engineering, Columbia University, New York City: for significant contributions to reactor physics and to nuclear cross sections, and for leadership in establishing a rational scientific basis for nuclear shield design.

Dr. Anthony L. Turkevich, Professor, Department of Chemistry, University of Chicago: for contributions to radiochemistry in activation analysis, to analysis of intranuclear cascades, and to utilization of radiochemical techniques throughout atomic energy.

Dr. Herbert F. York, Chancellor, University of California at San Diego, La Jolla, Calif.: for important contributions to our knowledge of elementary particles, and especially for leadership in applying atomic energy to the national defense.

Four panels of distinguished scientists and engineers in the fields of physics, chemistry and metallurgy, weapons and reactors assisted the General Advisory Committee in preliminary screenings of the nominations.

Award Established in 1959

The Commission established the award in December 1959, to perpetuate the memory of the late Dr. Ernest O. Lawrence, inventor of the cyclotron and Director of the Radiation Laboratory, Berkeley and Livermore, which bears his name. The laboratory is operated under contract for the AEC by the University of California. Five U.S. scientists were named to receive the first Lawrence Award in June, 1960, and five more were honored in April, 1961.

Authorized under Section 157b(3) of the 1954 Atomic Energy Act, as amended, the award is made to not more than five recipients in any 1 year in the amount of not less than $5,000 each and not more than a total of $25,000. It is presented in the spring of the year to men and women not more than 45 years of age who are citizens of the United States and who have made recent, especially meritorious contributions to the development, use, or control of atomic energy in areas of all sciences related to atomic energy, including medicine and engineering.

The Lawrence Award complements the Commission's Enrico Fermi Award, which authorizes a cash grant of $50,000, has no limit as to age

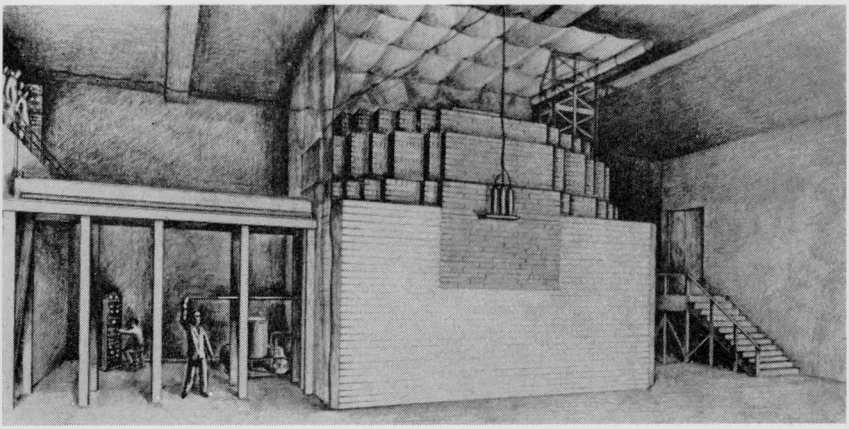
or citizenship of the recipient and may be presented for especially meritorious contributions to the development, use, or control of atomic energy at any time in the past.

Presidential Visit

A summary and photos of President Kennedy's visit to AEC facilities is included in the Space Propulsion section of Part Two—Nuclear Reactor Programs.

Part Two

Nuclear Reactor Programs



First Reactor. Artist's drawing of the world's first atomic reactor in which the first self-sustaining chain reaction of splitting atoms and releasing their energy under controlled conditions was achieved. Because of wartime secrecy, no photos were ever made of the completed reactor built by Enrico Fermi and his associates under the University of Chicago's old football field stands. The reactor was controlled by three sets of neutron-absorbing cadmium rods inserted at right angles to the uranium bars encased in the graphite pile. One set was automatic and could be controlled from the balcony (*upper left*) from which Fermi directed the reactor startup. A second set was rope-controlled (the rope would be cut by a scientist armed with an axe) for emergency use. The third control rod was hand-operated (*lower left*) and the one which actually held the reaction in check until withdrawn the proper distance. Primary purpose of the reactor was to test the feasibility of producing the materials for the bombs which brought World War II to a close. Although the reactor produced no power, it led to the development of today's nuclear power plants. The reactor and the grandstand, under which it was built, have since been dismantled. The location of the reactor is now marked by a bronze plaque which reads "On December 2, 1942, man achieved here the first self-sustaining chain reaction and thereby initiated the controlled release of nuclear energy." The drawing was executed by Melvin A. Miller of the Argonne National Laboratory staff in the fall of 1946 based on descriptions furnished him by the men who built the first "pile."

NUCLEAR POWER STUDY

On March 17, 1962, President Kennedy requested the Commission to ". . . take a new and hard look at the role of nuclear power in our economy . . . ." and to submit a report on its findings. The Commission's "Civilian Nuclear Power . . . A Report to the President—1962" [1] was submitted to the President on November 20. The following is the Introduction and Summary of the report.

INTRODUCTION

As a result of successes achieved during World War II, it was widely recognized thereafter that nuclear energy could, if properly developed, have important civilian applications. In addition to unique applications in scientific research, in medicine, in agriculture and in industrial operations, it was believed by many that nuclear energy could yield large economic advantages in such massive applications as the generation of electric power. It was also recognized, though not emphasized, that over the long term it would be an important resource, whose timely introduction would help conserve for special uses our finite supply of fossil fuels.

Atomic Energy Act Provisions

The long-term availability of abundant and economic sources of energy and the development of new techniques and technologies of general applicability are matters of concern to all the people and therefore to the government. Federal responsibility for the peaceful development of civilian uses of nuclear energy—for both short- and long-term ends—within our normal economic and industrial framework was clearly recognized by Congress in the Atomic Energy Act of 1946, and clarified and broadened in the Act of 1954. The latter states in Section 1 (Declaration) :

"It is . . . declared to be the policy of the United States that—

"b. the development, use and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise."

And in Section 3—(Purpose) :

"It is the purpose of this Act to effectuate the policies set forth above by providing for—

"a. a program of conducting, assisting, and fostering research and development in order to encourage maximum scientific and industrial progress ;

[1] The report is available from the AEC's Division of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., without charge.

"d. a program to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public;" and

"e. a program of international cooperation to promote the common defense and security and to make available to cooperating nations the benefits of peaceful applications of atomic energy as widely as expanding technology and considerations of the common defense and security will permit."

Many sections of the Act and many other acts of Congress expand on the above provisions and provide means and mechanisms for implementing them.

Power Generation Most Promising

In keeping with the responsibilities assigned it by the legislation, the Atomic Energy Commission has conducted vigorous programs of research, development, and exploitation directed at realizing the many peaceful benefits potentially to be derived from nuclear energy. Included in the applications are many, such as those of radioisotopes, where nuclear phenomena have special characteristics that are uniquely useful. The major effort has, however, been directed at extraction of energy in large amounts, primarily to accomplish conventional tasks or extensions of them. The most promising, and hence the most vigorously pursued among the various applications, is that of generating electric power. It is with the power program that this report primarily concerns itself.

The Commission has conducted and encouraged a national program, aimed, first, at obtaining the basic scientific and engineering data needed for proof of technical feasibility and safety of the more promising approaches to nuclear power generation and, second, at demonstrating the actual or potential economic feasibility of such approaches. This program has been strongly backed in both the executive and the legislative branches of the Government.

Early Programs

In its early phases the program was largely one of developing the technology. It leaned heavily upon, indeed it started from, knowledge gained from other reactor programs, notably "production" reactors for making plutonium, naval propulsion reactors and "research" and "test" reactors used for scientific purposes. In 1953 the Commission, with the encouragement of the Joint Committee on Atomic Energy, embarked upon a 5-year "experimental" program to develop reactors giving promise for civilian power applications. Construc-

tion was started on several experimental power-producing reactors on Commission sites, and one "prototype" reactor on a utility grid.[2]

The revision of the Atomic Energy Act in 1954, which encouraged industrial cooperation, and associated policy decisions by the Government resulted in continued expansion of the program by both government and industry. An important step was the addition, in 1955, of a "Power Demonstration" program under which the Commission and industry have cooperated in building and operating a number of nuclear power plants on utility grids. In one segment of this program, Commission-built and owned "prototype" reactors are operated by utilities that buy the steam; in another segment utilities are given research and development assistance in designing and constructing their own reactors and for a few years no charge is made for the lease of Government-owned nuclear fuel.

Ten-Year Program Initiated

In 1958, as the 5-year experimental program ended, the Joint Committee on Atomic Energy of the Congress published a report, prepared by its staff with the advice of consultants, recommending objectives for an expanded program and various steps that might be taken in furtherance of the program. During that and the following year, the Commission conducted, at the national laboratories and through contracts with the nuclear equipment industry, a series of detailed studies and evaluations of all the reactor concepts believed to hold promise for the development of economic nuclear power. The results were carefully analyzed by the Commission staff and, on two separate occasions, by advisory committees. On the basis of these studies, analyses and recommendations, the Commission published a series of reports, known to the trade as the "Ten-Year Program", which established short-range economic targets as well as long-range goals in economics, resource conservation and international leadership, and outlined a program for achieving these objectives. This has served as a general guide to the Commission during the intervening period.

Meanwhile, beginning with initiation of the "Atoms for Peace" program in 1954, and more intensively since the large International Conference on that subject in 1955, the Commission, in cooperation with the Department of State, has been very active internationally. The United States was the leader in the establishment of the International Atomic Energy Agency which conducts and sponsors cooperative programs throughout the world. The Agency will increasingly be responsible for administering safeguards against diversion of nuclear

[2] This Commission-built and -owned reactor, at Shippingport, Pa., provides steam at a plant of an investor-owned utility, which built the power generating equipment and operates the reactor under contract with the Commission.

materials to military use and for developing and recommending international regulations on safety and waste disposal. Cooperation and assistance have been rendered by the United States through formal agreements with such international organizations as Euratom, and with a large number of individual nations. Western Europe and, more recently, Japan have significant nuclear power programs in being as has the Soviet Union. Considerable interest in nuclear power has also been shown by many of the developing countries.

As a result of the various domestic programs, six sizeable reactors of the more highly developed types are in successful operation on utility grids (two of the largest and one other had no AEC assistance); seven more of small and medium size will be completed by the end of 1963; a few others are under construction or nearly so.

Future Possibilities

Sufficient developmental and operational experience has been accumulated to permit a reasonably accurate assessment of future possibilities. Nuclear electric power has been shown to be *technically* feasible, indeed, readily achieved. Power reactors can be reliably and safely operated. However, contrary to earlier optimism, the economic requirements have led to many problems—combining low capital cost with long life and assured reliability; lowering costs by improved efficiency; developing long-lived and, therefore, economic fuels. Attempts to optimize the economics by working on the outer fringes of technical experience, together with the difficulties always experienced in a new and rapidly advancing technology, have led to many disappointments and frustrations. Experiments have not always worked as planned. Many construction projects have experienced delays and financial overruns. Such difficulties led to considerable diminution of the earlier optimism regarding the early utilization of nuclear power, which in turn contributed to the withdrawal of some equipment and component manufacturers from the field.

Happily, more recently much progress has been made toward solutions of these problems. Expectations are being more nearly, and in some cases completely, realized. Nuclear power is believed to be on or near the threshold of competitiveness with conventional power for large plants, in areas of the country where fossil fuel costs are high. Further cost reductions are definitely in sight, provided an aggressive program is continued.

The developments to now have verified that, if extensively used, nuclear power could have important implications—as a means of exploiting a large, new energy resource; as an economic advantage, especially to areas where fossil fuel costs are high; as an important contributor to new industrial technology and to our technological

world leadership; as a significant positive element in our foreign trade; and, potentially, as a contributor to the nation's defenses. Its potential benefits will actually be realized, however, only if it can be made economically attractive.

Advanced Reactors Needed

To surmount the economic hurdle is the most immediate program goal. Unfortunately the reactors that will do so can extract only about one percent of the energy potentially available in our reserves of nuclear materials. To utilize the rest, which must be done if nuclear energy is to be of lasting usefulness, requires the development to an economic status of more advanced and difficult reactors. This will be a rigorous and expensive task.

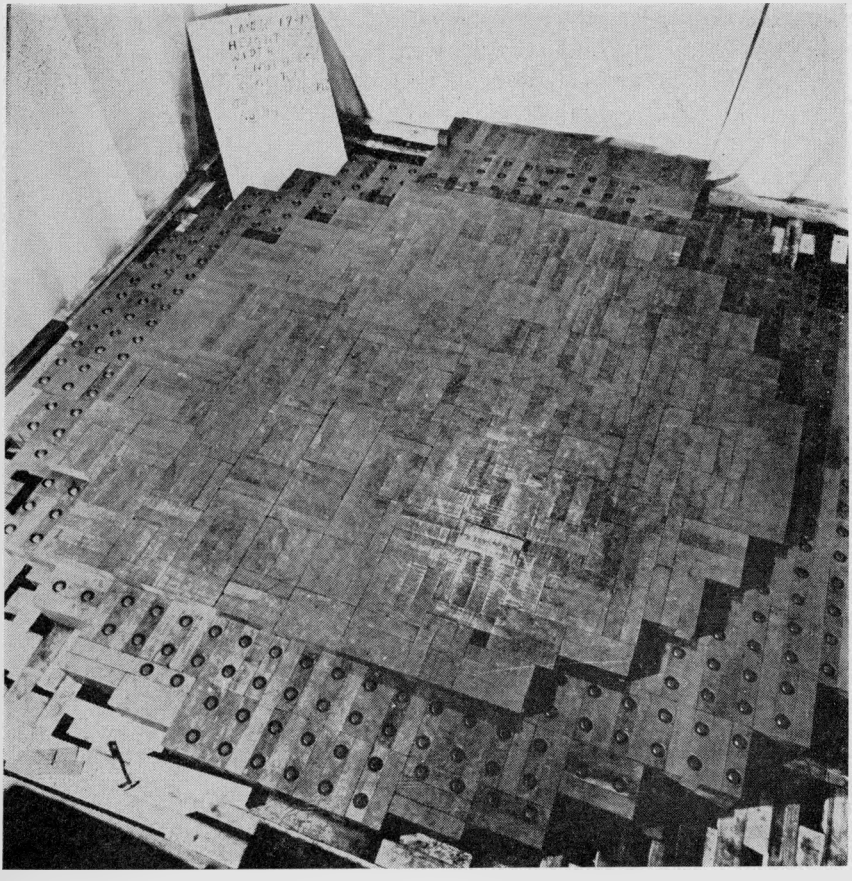
How best to pace the short- and long-term efforts, what relative emphasis to give to each, how diversified and intensive the total effort should be—these are the principal program questions.

The stage of development has also brought forward a number of important policy questions. Many of them relate to nuclear fuels. With extensive applications potentially in the offing, the question naturally arises as to the desirability of changing, at a reasonably early date, to private ownership of special nuclear materials. Its adoption would give rise to the corollary question of policy relating to the "toll" enrichment of privately owned uranium in the government's diffusion plants, a service which private industry cannot economically provide for itself; this question arises internationally in any case. Action must be taken on the Commission's raw uranium procurement program, contracts for which expire in 1966, and on extension and adjustment of its schedule of guaranteed prices for plutonium produced in non-government reactors, which expires in 1963.

Clearly the time has come for a major review and reassessment—a review more of basic policies than of detailed technical activities; a review of where the nuclear electric power program should be headed, at what rate and with what amount of government participation. It is to these ends that this study has been made.

A study of this nature requires special knowledge in many fields outside the detailed cognizance of the Atomic Energy Commission. Among these are current and projected rates of use of energy, including electric power requirements, our reserves of fossil fuels, and economic trends in these and related fields. We have, therefore, worked closely with, and relied heavily upon, other agencies and groups that are expert in these fields. We have also taken advantage of studies and evaluations that have been, or are being made by others in such fields as the international impact of nuclear energy, the civilian defense and national security aspects of the problem, and the air pollu-

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Fermi "Pile". Twenty years ago, Enrico Fermi and an international group of fellow scientists piled layers of graphite and uranium together and created the world's first self-sustaining atomic chain reaction under controlled conditions. This is the only photograph made during the construction of the first nuclear reactor. The photograph was made in November 1942, as the 19th layer of graphite was being added. Alternate layers of graphite contained uranium metal and uranium oxide and were spaced by layers of "dead" graphite. Layer 18, almost covered in this potograph, contained uranium (small circles in graphite bricks). Actual construction was carried on in this manner to the 57th layer, which was about one layer beyond the critical or operating dimensions. The roughly spherical form of the structure is shown as is some of the supporting wooden framework. The reactor was constructed under the west stands of Stagg Field at the University of Chicago and was operated for the first time on December 2, 1942.

tion problems of fossil fuel plants. Of especial value have been recent reports, some in draft form, prepared by the Department of the Interior, the Federal Power Commission, the National Academy of Sciences, the Committee on Interior and Insular Affairs of the United States Senate, the General Advisory Committee to the Atomic Energy Commission, and the Advisory Committee on United States Policy Toward the International Atomic Energy Agency.

Industrial Seminars Aided Report

We have had helpful discussions on the content of the report with the Bureau of the Budget, the Office of Science and Technology, the President's Science Advisory Committee, the Council of Economic Advisors, the Department of the Interior, the Federal Power Commission, the General Advisory Committee, and the Joint Committee on Atomic Energy of the Congress. However, the contents of the report are the responsibility solely of the Atomic Energy Commission.

During the early weeks of the study a series of seminars was held at which representatives of AEC contractor organizations, various industries and others made presentations of their own civilian power programs.

SUMMARY

The Need for Nuclear Power

Our technological society requires ample sources of energy. Although large, the supplies of fossil fuels are not unlimited and, furthermore, these materials are especially valuable for many specific purposes such as transportation, small isolated heat and power installations, and as sources of industrial chemicals. Reasonable amounts should be preserved for future generations.

Comparison of estimates of fossil fuel resources with projections of the rapidly increasing rate of energy consumption predict that, if no additional forms of energy were utilized, we would exhaust our readily available, low-cost fossil fuels in a century or less and our presently visualized total supplies in about another century. In actual fact, long before they become exhausted we will be obliged to taper off their rate of use by supplementing them increasingly from other sources.

Unlimited Latent Energy

In contrast, our supplies of uranium and thorium contain almost unlimited amounts of latent energy that can be tapped provided "breeder" reactors are developed to convert the fertile materials,

uranium 238 and thorium 232, to fissionable plutonium 239 and uranium 233, respectively.[3] Successfully done, this will render relatively unimportant the cost of nuclear raw materials so that even very low-grade sources will become economically acceptable.

The use of nuclear energy for electric power and, less immediately for industrial process heat and other purposes is technically feasible and economically reasonable. In addition to its ultimate importance as a means of exploiting a large new energy resource, nuclear electric power holds important near-term possibilities: as a means of significantly reducing power generation costs, especially in areas where fossil fuel costs are high; as an important contributor to new industrial technology and to our technological world leadership; as a significant positive element in our foreign trade; and, potentially as a means of strengthening our national defense.

In view of the above we have concluded that: *Nuclear energy can and should make an important and, ultimately, a vital contribution toward meeting our long-term energy requirements, and, in particular, that: The development and exploitation of nuclear electric power is clearly in the near- and long-term national interest and should be vigorously pursued.*

The Role of the Federal Government

The technological development of nuclear power is expensive. The reactors are complex, and operating units, even of a scaled-down test variety, must of necessity be large and costly. Furthermore, nuclear power does not meet a hitherto unfilled need but must depend for marketability on purely economic advantages that will return the development investment slowly. Hence, the equipment industry could not have afforded to undertake the program by itself. The Government must clearly play a role.

An early objective should be to reach the point where, with appropriate encouragement and support, industry can provide nuclear power installations of economic attractiveness sufficient to induce utilities to install them at their own expense. Once this is achieved the Government should devote itself to advanced developments designed to meet long-range objectives, leaving to industry responsibility for

[3] The readily fissionable material found in nature is confined to uranium 235 which constitutes only 0.7 percent of normal uranium. The energy contained in this isotope in uranium mineable at near present costs is only a small fraction of that contained in our fossil fuel reserves. Fortunately, the so-called "fertile" isotopes, uranium 238, constituting the remainder of normal uranium, and thorium 232 constituting practically all normal thorium can be converted to fissionable plutonium 239 and uranium 233 by absorption of neutrons in a nuclear reactor.

nearer-term improvements. Gradually, as technological maturity is reached, the transition to industry should become complete.

Thus, *the proper role of Government is to take the lead in developing and demonstrating the technology in such ways that economic factors will promote industrial applications in the public interest and lead to a self-sustaining and growing nuclear power industry.*

The Present Situation

Accordingly, in keeping with national policy, and with the responsibilities assigned to it by the Atomic Energy Act, the Atomic Energy Commission has conducted and encouraged a vigorous program directed toward the development and extensive exploitation of nuclear energy for civilian purposes, with emphasis on nuclear electric power. About $1.275 billion has been expended by the AEC to date [4] on the civilian power program. This program has included both research and development and a "power demonstration" program, involving aid in the construction and operation of practical reactors on utility grids. Several reactor types are under development. Most highly developed are "converter" reactors that produce less fissionable material than they consume; much less far along are "breeder" reactors that produce more than they consume.

In one segment of the power demonstration program, Commission-built and owned "prototype" reactors are operated by utilities that buy the steam; in another segment, utilities are given research and development assistance in designing and constructing their own reactors and, for a few years no charge is made for the lease of Government-owned nuclear fuel. Six sizeable reactors of the more highly developed types are in successful operation on utility grids (the two largest without AEC assistance); seven more will be completed by the end of 1963; a few others are under construction or nearly so.

Experience has shown that nuclear electric power is readily achieved technically but difficulties have been met in developing a technology that is economically competitive with conventional power generation methods. Happily, in recent years these difficulties have been progressively overcome.

Certain classes of power reactors, notably water-cooled converters producing saturated steam are now on the threshold of economic competitiveness with conventional power in large installations in high fossil fuel cost areas of the country. Foreseeable improvements will substantially increase the areas of competitiveness.

[4] We estimate that industry has expended approximately $0.5 billion of its own funds, mostly for plant and equipment.

Technical Considerations

Saturated steam reactors, however, have certain inherent limitations. They produce relatively low temperature saturated steam which limits their efficiencies and requires the use of large, expensive turbines; they are only moderately effective converters.[5] Consequently, converter concepts utilizing other moderators and coolants and promising improved economics and fuel utilization are being actively pursued with encouraging results; early competitiveness seems assured for some of them. All of these are "thermal" [6] reactors. They include the "spetral shift" reactor, the high temperature gas-cooled reactor, and the sodium-graphite reactor. All have relatively high efficiencies and excellent economic promise. The first two will have excellent conversion ratios; indeed they may eventually be made to breed in the thorium-uranium cycle.[7] The sodium-graphite reactor can achieve quite high temperatures, has good safety features and helps develop the liquid sodium technology necessary for fast breeders. The heavy water moderated reactor also shows promise of high conversion ratios but present designs are not so attractive economically as other types in the United States. The organic-cooled and moderated reactor may have application for process heat. Some of these should be carried to the stage of operating prototypes during the next several years, and some will reach the full-scale operational phase by the early 1970's. Operating reactors of these types will help accelerate the industry, will increase operating experience and will help provide plutonium needed for the breeder program.

Long Transition Stage for Breeders

Although much technical progress has been made, breeder reactors have not yet reached an economically useful stage of development. Even when they do, they will not, initially at least, make new material fast enough to provide the fuel for new plants at the rate required if nuclear power is to increase its proportional share of the national electric power load. Hence, even after breeders become available, it will be necessary to fuel some portion of the installations with uranium 235 until such time as improved breeding gains and reductions in the relative rate of growth in power consumption enable the breeders to be self-sufficient. For the thermal reactors used to make

[5] They convert 0.5 to 0.7 as much material as they consume. Compounded, this results in doubling to tripling the energy finally made available.

[6] In a "thermal" reactor most of the fission neutrons are slowed-down (moderated) before interacting with the nuclear materials; this is accomplished through many collisions with light nuclei such as hydrogen (in water or organic compounds), carbon (in graphite) or beryllium. In a "fast" reactor, little or no moderation is used, so that most of the neutrons retain the high energies and velocities with which they were emitted in the fission process. "Intermediate" reactors lie between.

[7] See footnote 3, page 110.

U–233 from thorium, this need can be met by substituting U–235 for U–233 in some of them, at a sacrifice in fuel produced. A similar procedure would, however, be uneconomic in the "fast" reactors required to breed plutonium. Hence, in the transition stage, which will last for many decades, fast breeders that burn as well as make plutonium will probably be augmented by thermal converters burning U–235 and producing plutonium at a slower rate. This need will enhance the desirability of the more advanced converters both for economic reasons and because it is important that the combination of breeders and converters reach an overall net breeding capability, or very nearly so, while relatively cheap fuel supplies are still available.

Economic Power Near

In our opinion, economic nuclear power is so near at hand that only a modest additional incentive is required to initiate its appreciable early use by the utilities. Should this occur the normal economic processes would, we feel, result in expansion at a rapid rate. The Government's investment would be augmented manyfold by industry. Equipment manufacturers could finance major technical developments, thus reducing the future need for Government participation.

Continuation of the Commission's present effort, with some augmentation in support for the power demonstration program, and with program adjustments to give added emphasis to breeders, would, we believe, provide industry with the needed stimulus to build a significant number of large reactors in the near future, would bring nuclear power to a competitive status with conventional power throughout most of the country during the 1970's, and would make breeder reactors economically attractive by the 1980's.

Under these conditions, we estimate that by the end of the century nuclear power would be assuming the total increase in national electric energy requirements and would be providing half the energy generated.[8] This rate of progress, projected into the next century, would be an important step in conservation of the fossil fuels and, unless breeders lagged the converters much more than we predict, would raise no problems in nuclear fuel supplies.

$30 Billion Savings

Under conservative cost assumptions, it is estimated that by the end of the century the above projected use of nuclear power would result

[8] Since, by Federal Power Commission estimates, the total use of electric energy will grow tenfold in the same period, fossil fuel consumption for this purpose would still increase by a factor of from four to five.

in cumulative savings in generation costs of about $30 billion.[9] The annual saving would be between $4 and $5 billion. High cost power areas would no longer exist, since, in the absence of significant fuel transportation expenses, the cost of nuclear power is essentially the same everywhere. This would be an economic boon to areas of high cost fossil fuels and, by enabling them to compete better, should increase the industrial potential of the entire country.

More generally, the introduction of nuclear power technology on a significant scale would add to the health and vigor of our industry and general economy. Technical progress would assist the space and military programs and have other ancillary benefits. Our international leadership in the field would be maintained, with benefit to our prestige and our foreign trade. Nuclear power could also improve our defense posture; it would not burden the transportation system during national emergencies; furthermore, the "containment" required for safety reasons could, if desired, be achieved at little, if any, extra cost by underground installations, thus "hardening" the plants against nuclear attack.

A substantially lesser program would sharply reduce these benefits. Too great a slowdown could result in losing significant portions of industry's present nuclear capability thereby seriously delaying the time at which it would assume a major share of the development costs.

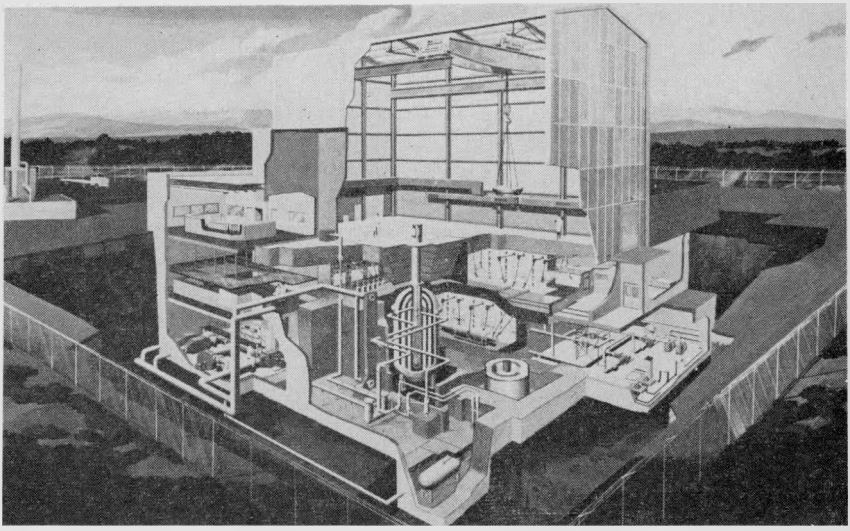
Major Program Step-up Not Needed

On the other hand we do not believe that a major step-up in the whole Commission program is appropriate. Taken as a whole, support of the scientists and engineers engaged in developmental work is about adequate and, in view of the country's other needs, it would seem unwarranted to increase appreciably such manpower in this field.

To summarize we have concluded that *the nuclear power program should continue on an expeditious basis. Commission support should continue with added emphasis on stimulating industrial participation. The program should include: (1) early construction of plants of the presently most competitive reactor types; (2) development, construction and demonstration of advanced converters to improve the economics and the use of nuclear fuels; (3) intensive development and, later, demonstration of breeder reactors to fill the long-range needs of utilizing fertile as well as fissile fuels.*

An important corollary area is the development of economical chemical reprocessing methods whereby useful fissile and fertile mate-

[9] At 5 percent interest these cumulative savings would have a discounted value of about $10 billion in 1970.



New Test Facility. A 20 Mw Fast Reactor Core Test Facility is being planned at the Los Alamos Scientific Laboratory. The design will permit operational testing of a series of experimental cores using plutonium alloy fuel in molten form. Experimental systems will be operated at specific powers up to 500 watts per gram for studies of fission gas purging from the liquid fuel, container resistance to corrosion, radiation damage to container and fuel, and continuous fuel processing methods. Currently, the Title II drawings have been completed for the building and plant (Phase A), and construction is pending approval of the safety analysis report.

rials are recaptured from used fuel assemblies and the fission products are removed. Another important line of work concerns the ultimate storage or disposal of the large amounts of radioactive fission products that will be generated when a major power industry comes into being.

An overriding consideration is that of safety. Not only must inherent safety be assured in fact but its existence must be conclusively demonstrated to the public. With adequate technical improvements and the accumulation of satisfactory experience, it should be possible gradually to remove many of the siting restrictions in force today, thus permitting plant locations closer to the large load centers.

Possible Construction Program

A composite construction program for the next dozen years might entail the following: (1) the construction and placing into operation of seven or eight power-producing prototype reactors, approximately half of which would be advanced converters and the rest breeders;

most of their cost would probably be borne by the AEC; (2) assistance, as necessary, to industry in the construction of 10–12 full-scale power plants of improving design as time goes on; hopefully, industry will concurrently bear full costs of many more of well proven design.

This construction would, of course, be backed by specific development programs directed at the more advanced reactor types, especially breeders, and by research and development related to the underlying technology.

Legal, Financial, and Administrative Matters

Careful attention must be paid to several legal, financial and administrative questions, among them (*a*) private ownership of nuclear materials and related policies on fuel pricing and "toll enrichment"; (*b*) policies relating to the raw material and other supporting industries; (*c*) licensing and regulation, including reactor siting criteria.

The Commission has recommended that private ownership of special nuclear materials be authorized at an early date, thus permitting the free play of normal economic forces and minimizing economic distortions of the technology. To prevent sudden dislocations such ownership should not be made mandatory for a decade or so.

The Commission further believes that a policy of "toll enrichment" or equivalent should be adopted. Industry could then buy its raw materials on the open market, use privately owned plants to prepare them for enrichment, and depend upon the Government only for the actual enrichment in the diffusion plants. This service should also be extended to our friends abroad, subject to proper safeguards against diversion for military use.

Uranium-Plutonium Price Scale Determination

Before and during the period of transition to private ownership the value set by the Commission on enriched uranium for lease or sale should, as at present, be determined by the actual cost, with appropriate allowances for depreciation and other indirect expenses. The Commission has recommended that prices for the purchase of plutonium be in accordance with its "near-term" value as a reactor fuel. We believe that consideration should be given to scaling the price in accordance with the content of fissionable isotopes. The same pricing policies should apply to purchases abroad of plutonium made from uranium enriched in the United States.

The Commission's contracts with uranium miners and processors expire at the end of 1966. Since it seems probable that the requirements for new uranium for weapons, the dominating use to date, will decrease in the next decade, careful planning is necessary to so guide

further procurement that the uranium industry will be kept viable during any slack period before civilian power creates another large demand. With this in mind the Commission is planning to offer the industry a "stretch-out" program under which an AEC commitment to purchase additional material after January 1, 1967 would be used as an incentive to induce industry to delay until after that date delivery of part of the uranium presently under contract. If successful, this program would result in a leveling-off process that should carry through the period of slack use without injuring the industry substantially or resulting in an unreasonably large surplus.

The Commission intends to continue and extend encouragement to the industrial activities ancillary to the major equipment industry. Many that could start on a small scale are already well under way. There are, however, a few activities, such as the chemical separation of used fuels, that are attractive to industry only on a fairly substantial scale and for which there will be little private business until civilian reactors have operated for an appreciable period. Strong encouragement is being given to private industry to embark in these fields with some prospect of success. As rapidly as a private capability comes into being the Commission should withdraw from all such work deriving from industry and should utilize private plants to fill its own requirements except, perhaps, for those related to materials for weapons.

Recognizing that simplifying and streamlining licensing and regulatory procedures can be a major help in encouraging the utility industry to adopt nuclear power, the Congress and the AEC have been taking steps in this direction. A major step is the recent enactment of laws that will reduce greatly the number of mandatory public hearings for reactor licensing. The Commission is studying means of simplifying its own licensing procedures by reducing the volume and complexity of administrative processes. Further operating experience should reduce the time and effort required for technical analysis and review.

Objectives for the Future

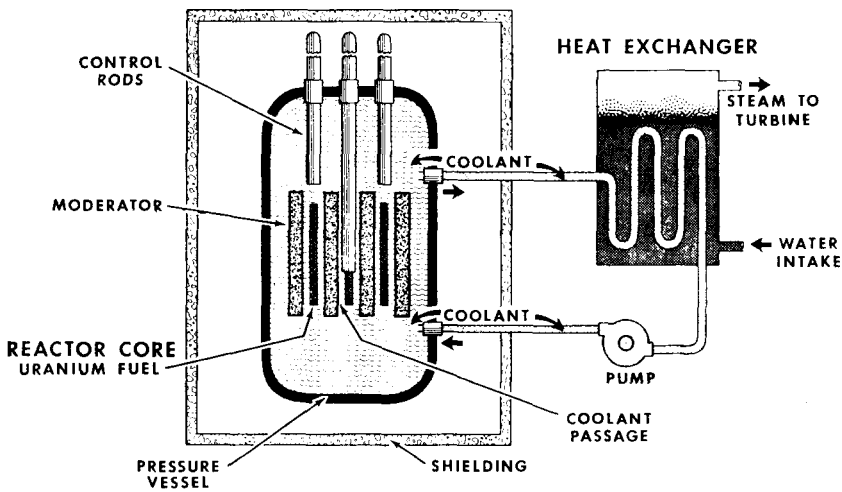
Clearly: *The overall objective of the Commission's nuclear power program should be to foster and support the growing use of nuclear energy and, importantly, to guide the program in such directions as to make possible the exploitation of the vast energy resources latent in the fertile materials, uranium 238 and thorium.*

More specific objectives may be summarized as follows:

1. *The demonstration of economic nuclear power by assuring the construction of plants incorporating the presently most competitive reactor types;*

2. *The early establishment of a self-sufficient and growing nuclear power industry that will assume an increasing share of the development costs;*
3. *The development of improved converter and, later, breeder reactors to convert the fertile isotopes to fissionable ones, thus making available the full potential of the nuclear fuels;*
4. *The maintenance of U.S. technological leadership in the world by means of a vigorous domestic nuclear power program and appropriate cooperation with, and assistance to, our friends abroad.*

The role of the Commission in achieving these objectives must be one of positive and vigorous leadership, both to achieve the technical goals and to assure growing participation by the equipment and utility industry as nuclear power becomes economic in increasing areas of this country and the world at large.



Reactor Components. Basically, a nuclear reactor is an atomic furnace in which the fissioning, or splitting, of atoms of nuclear fuel can be controlled and put to useful work. This simplified diagram shows the major components in a typical water-type power reactor of today. As the coolant passes around and through the reactor core, it picks up the heat given off by the fissioning of uranium atoms. The heated coolant is piped off to a heat exchanger were it turns water in a secondary system of pipes into steam. The steam, in turn, is piped to a turbine-generator for production of electricity. The reactor is controlled by movable rods made of a neutron-absorbing material. As the control rods are inserted into the core they absorb neutrons released by the fissioning process, thus slowing down the generation of heat produced by the fissioning of uranium atoms. Each fission action of an atom releases two or three neutrons which, when striking uranium atoms causes them to split, or fission. Thus, as the control rods are removed from the core fewer neutrons are absorbed and the rate of fissioning increases rapidly. The "moderator" is a material which slows the speed of the neutron's flight so that it will split an atom rather than glance off its surface.

NUCLEAR REACTOR DEVELOPMENT

The Commission's nuclear power report to the President points up that, if extensively used, "nuclear-electric power holds enormous possibilities—as an important means of exploiting a large new energy resource; as an economic boon, especially to areas where fossil fuel costs are high; as an important contributor to new industrial technology and to our technological world leadership; as an important element in our international posture; and potentially as a means of strengthening our national defense." The report further points out, however, that the potential benefits of nuclear power will be realized only if it can be made economically attractive. "Thus," the Commission's report concludes, "the proper role of Government is to take the lead in developing and demonstrating the technology in such ways that the economic factors will automatically promote industrial application in directions that continuingly advance the public interest, including the long-range conservation of resources."

AEC's Responsibilities

Early recognition of the enormous possibilities of nuclear-electric power led the Congress, through passage of the Atomic Energy Act of 1946 and later through the revised Atomic Energy Act of 1954, to assign to the Atomic Energy Commission the responsibility for conducting continuing programs of research, development, and exploitation directed at realizing the many peaceful benefits potentially to be derived from nuclear energy. Within the framework of this legislation, the AEC—initially alone, and later in cooperation with industry—has, through its Division of Reactor Development carried out a national program aimed, first, at obtaining the basic scientific and engineering data needed for proof of technical feasibility of the more promising approaches to nuclear power generation, and second, at demonstrating the actual or potential economic feasibility of such approaches. Specifically, the Commission's Division of Reactor Development is responsible for those phases of the national program which are directed toward:

1. Accumulating basic technology upon which advanced reactor concepts and refinements to existing nuclear reactor concepts may be based;
2. The development and improvement of nuclear reactors and associated equipment, processes, materials, and facilities for:
   a. the production of electricity, process steam and space heat;
   b. the propulsion of space, maritime, and military vehicles; and
   c. specialized civilian and military applications; and

3. Improving the safety of nuclear reactor operations in terrestrial and aerospace environments.

BASIC TECHNOLOGY [10]

Many of the research and basic developmental projects carried out in support of progress in reactor development have general application to reactor systems and cannot, therefore, be categorized under any specific reactor development program. These projects in "general reactor technology" are directed toward providing basic technology on reactor systems and related problems; carrying out engineering development of a general and fundamental nature; and investigating the feasibility and potential of new methods for improving reactors and associated nuclear devices.

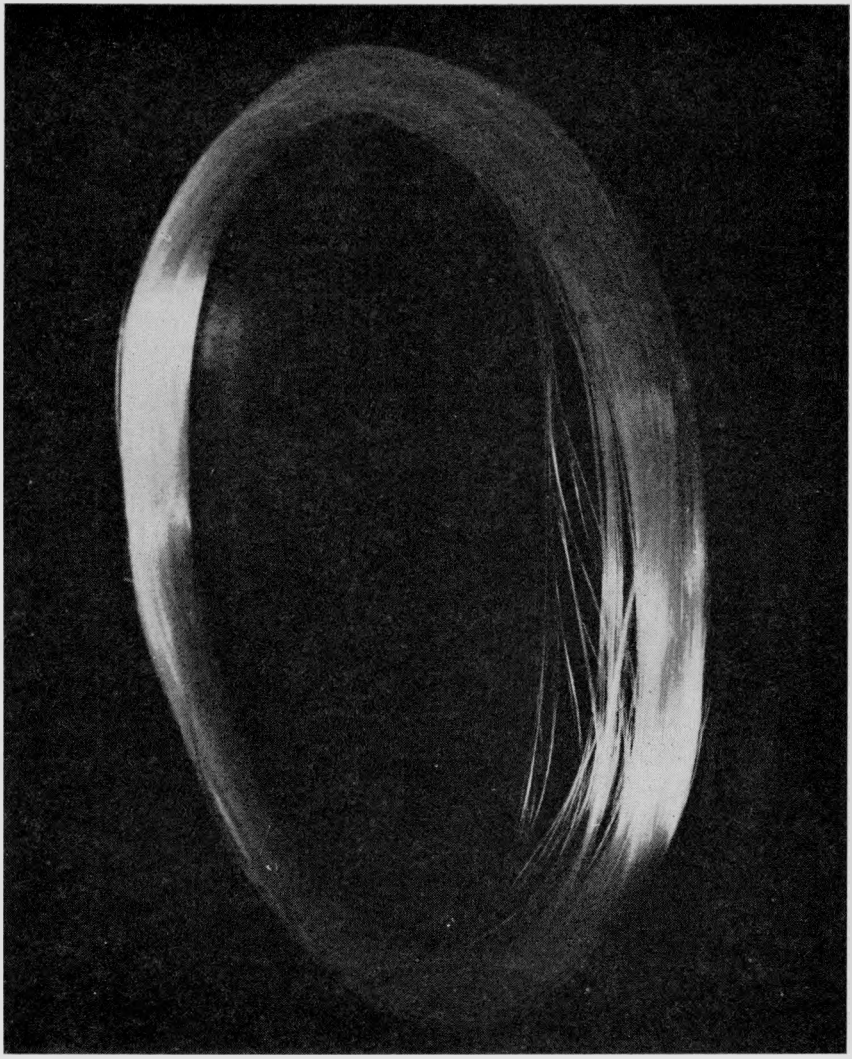
TEST IRRADIATION SERVICES

The Materials Testing Reactor (MTR) which went critical in 1952, the Engineering Test Reactor (ETR) which began operations in 1957, and the Advanced Test Reactor (ATR) which is presently under construction and is scheduled for completion early in 1965, are reactors which provide generalized facilities in which materials and components intended for use in power reactors can be subjected in advance to an environment comparable to that which will prevail in the power reactor. All three of these reactors are owned by the AEC and are located at the National Reactor Testing Station (NRTS) in Idaho.

In addition to these three test reactors, the AEC has a contract with the General Electric Co. under which GE provides test irradiation and related services for the AEC and its contractors in the General Electric Test Reactor (GETR) near Pleasanton, Calif. Until this year, the Commission also had contracted with the Westinghouse Electric Corp. to provide similar services for the AEC and its contractors in the Westinghouse Testing Reactor (WTR) near Waltz Mill, Pa. In March, however, Westinghouse notified the AEC that "because the amount of present and immediately foreseeable business is insufficient to meet operating costs" it was permanently shutting down and retiring its test reactor.

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[10] More complete details of advancements made under the basic reactor technology program are included in the supplemental report, "Fundamental Nuclear Energy Research—1962", available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.



Possible Fuel. Plutonium oxide has been successfully incorporated into silicate glass formulations. The plutonium oxide is so tightly bound in the glass matrix that danger from handling these glasses has been eliminated. A glass may be fabricated into various shapes and forms. The coil of glass fibers in the picture *above* was drawn from a glass billet containing ten weight percent plutonium oxide by the monofilament technique. These plutonium-bearing glasses developed at the AEC's Mound Laboratory are presently being evaluated as a potential reactor fuel at Argonne National Laboratory.

GENERAL REACTOR TECHNOLOGY PROGRAM

The Commission is supporting four general reactor technology programs—reactor physics, fuels and materials development, engineering and component development, and chemical separations—which apply to long-range civilian, military, and space reactor problems and problems that are common to a variety of reactor concepts.

Reactor Physics

Under the reactor physics program, studies are made of the interaction of neutrons with reactor materials and also with lattices composed of fuel and moderator combinations. These studies provide fundamental data necessary for the calculation of reactor performance. Such data, and methods of using these data, contribute to the design of reactors having higher power densities, more effective operation and control, greater reliability, and ultimately, lower costs.

In one study being carried out under this program by the Phillips Petroleum Co.—the Commission's principal research contractor at NRTS—measurements of radioactivity and decay properties of MTR-produced radioactive nuclides are made to provide information for shielding design and reactor physics calculations. Another study is designed to advance the use of thorium in reactors. Irradiation of thorium produces uranium 233 (U–233) a possible reactor fuel. After irradiation in the MTR or ETR, the thorium sample is transferred to the Advanced Reactivity Measurement Facility (a reactor of small size and high sensitivity) where the rate of buildup of U–233 and other nuclides is analyzed nondestructively.

The Rensselaer Polytechnic Institute (RPI) at Troy, N.Y., is using an AEC-owned electron linear accelerator (LINAC) to provide pulsed neutron sources for a wide variety of cross section and reactor physics experiments. Neutron pulses are produced by allowing the LINAC pulsed electron beam to bombard a heavy metal target. The gamma radiation resulting from the deceleration of electrons in the target material interacts immediately with target nuclei to produce neutrons.

Neutron cross section measurements, as well as investigation of flux spectra and neutron kinetics in miniature lattices are also under way in a joint Rensselaer-Oak Ridge National Laboratory program and are expected to produce information of considerable value for the understanding and development of reactor systems.

A program of minimum reflection critical experiments was started at Brookhaven National Laboratory (BNL) with first criticality achieved on a bare uranium-graphite assembly containing 8.11 kilograms of U–235. This facility was especially designed to minimize

back-scattering of neutrons from the floor and building structure into the critical lattice which has plagued the interpretation of previous experimental measurements on graphite and uranium systems. The critical assembly is supported well away from walls and above floor level by a lightweight metal structure. The studies planned with this facility will include a number of different assembly sizes and compositions, containing graphite or beryllium as the moderator.

Fuels and Materials Development

The reactor fuels and materials development program is concerned with obtaining information about how fuels and materials perform at various service temperatures and in different reactor environments; with lengthening the lifetime of reactor fuels; and with developing potential new reactor materials for high temperature service.

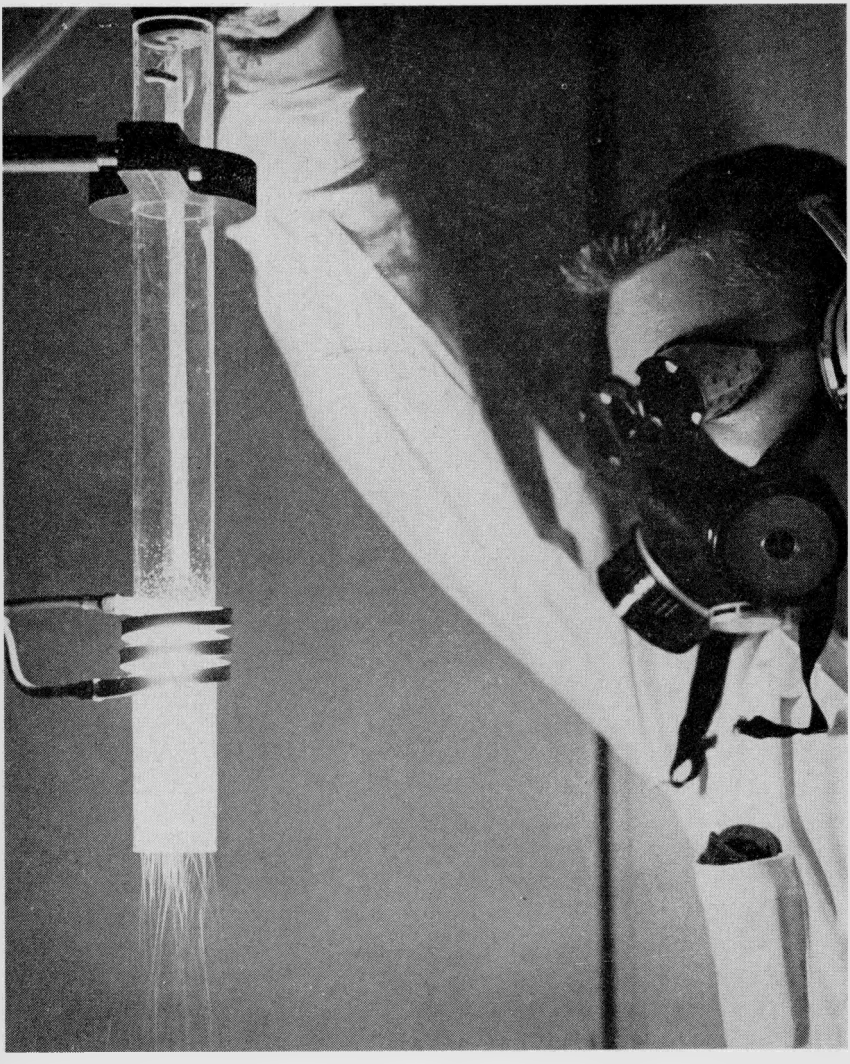
Under this program, Phillips Petroleum Co. has continued studies of uranium-aluminum systems in the MTR environment in the hope of extending the use of aluminum to the 600–700° F. range. Studies of fuel element geometries and heat transfer have also continued. An in-pile fatigue testing loop is being constructed for insertion into the ETR for the purpose of evaluating fatigue life of structural steels to be used in reactor components. Specimens of the steels, placed inside the loop within the core of the reactor, will be stressed—by rotating, bending, compressing, and/or stretching—and their deformations measured while they are subjected to the ETR's intense neutron irradiation.

The Commission's Mound Laboratory at Miamisburg, Ohio—operated, under AEC contract, by Monsanto Research Corp.—is engaged in research on obtaining fundamental information on plutonium-bearing materials which are potential reactor fuels. Their program is divided into the determination of phase equilibria and structures of plutonium and its alloys, the determination of their physical properties, and the formulation and evaluation of plutonium-bearing glass and oxide systems.

The phase equilibria and structures of plutonium-bearing alloys are determined at Mound Laboratory by differential thermal analysis and metallographic examination. The electron probe X-ray analyzer is used to characterize intermetallic compounds formed in an alloy system. The plutonium-cerium-copper ternary phase diagram has been completed and the five transformations in plutonium have been determined. In addition, the physical properties of the binary and ternary system have been measured.

Mound is also determining the interfacial tension between plutonium metal and molten sodium over a wide temperature range. This concept is attractive for advanced reactor concepts in which the liquid

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Fast Breeder Fuel. The use of plutonium-ceramic materials has been anticipated in power reactors of the fast breeder type and is being studied at the Commission's Mound Laboratory and Argonne National Laboratory. Plutonium oxide has been successfully passed through a inductively coupled argon plasma torch to form contamination-free microspheres. In this picture, a research chemist is shown dropping plutonium oxide powder through the plasma. The glass-like spheroidized plutonium oxide may be seen emerging as white streamers from the bottom of the apparatus.

plutonium is pumped through the heat exchangers in molten sodium. Studies on this concept are continuing.

Plutonium oxide has been successfully incorporated as an integral constituent of silicate glasses. The toxicity hazard of plutonium handling is practically eliminated because the plutonium is so tightly bound in the glass structure. In addition to their application as fuels for chemo-nuclear and power reactors, plutonium-bearing glasses have been successfully fabricated into alpha and neutron sources.

These plutonium-bearing glasses have been fabricated into rods, fibers, and small spheres for evaluation at Argonne National Laboratory in advanced reactor concepts. The glasses retain the plutonium, but permit the fission product wastes to escape from the matrix. The chemical durability of the glasses has been determined at Mound Laboratory, and they have been found to be stable in acids, alkalies, and hot water.

Ceramic fuel systems are being used in present-day nuclear power reactors and the incorporation of plutonium ceramic materials as a fuel has been anticipated. The physical and chemical characteristics of plutonium dioxide at elevated temperatures are being studied. The oxide is prepared by passing plutonium oxide through an inductively coupled argon plasma torch which melts the plutonium oxide to form a hard, clear microsphere. These plutonium oxide microspheres are contamination-free and resistant to attack by dilute acids and alkalies. The uranium dioxide-plutonium dioxide binary phase system is currently being studied.

Engineering and Component Development

Activities of the engineering and component development program are directed toward solving fundamental engineering problems, such as, how the heat generated in a reactor can be more efficiently used; how to measure neutron flux levels, and coolant pressure, temperature, flow, and density in high temperature, high radiation environments; and how various components for reactors not yet in existence can be developed in advance so they will be available when needed.

Some of the major 1962 accomplishments of the engineering and component development program were the development of several new instruments to measure coolant conditions inside water-cooled reactor cores and to measure neutron flux in nuclear reactors. A new type computer for indicating the stability and dynamic performance of nuclear reactor plants through analysis of the neutron flux level fluctuations also was constructed and tested. The device, called a Transfer Function Computer, is expected to find wide application both as a diagnostic tool and as an operating performance monitor in many power reactor plants. A hydraulic mechanism for moving control rods in large-size reactors has also been developed and tested

through the proof-of-principle stage. This device, which has been tested with a 2,300-pound load and operated through a total travel of 413 feet, will find principal application in water-cooled reactor designs of the 500 thermal megawatt size and larger.

Work under way to develop high temperature liquid metals as reactor coolants and working fluids also advanced greatly during the year. The feasibility of sustained operation of a boiling cesium system at severe conditions was demonstrated in early 1962 when a loop made of columbium, in which boiling and condensing of cesium was investigated, successfully completed a 2,000 hour test at temperatures up to 1,850° F. At Oak Ridge National Laboratory, the first high temperature, forced circulation boiling potassium heat transfer and burnout data were obtained, and at Argonne National Laboratory the construction of a loop to study the fluid dynamics of boiling sodium was successfully completed.

Results of these and other studies will greatly advance the state of technology for high temperature space power and propulsion systems.

Chemical Separations and Development

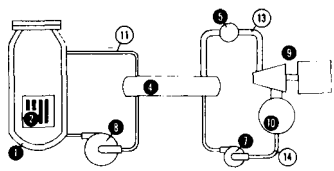
Development of technology for the recovery of still usable fuel from spent reactor elements is being continued to further reduce power reactor fuel cycle costs and to maintain a basic capability for reprocessing the exotic fuels resulting from the space and advanced military reactor development programs.

Also conducted under this program are chemical and chemical engineering studies which support advanced reactor concept development.

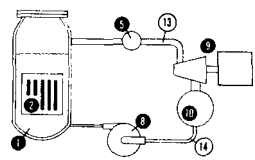
A significant accomplishment in the program in 1962 was an engineering scale hot pilot plant demonstration at Oak Ridge National Laboratory of volatility technology with fully irradiated fuel. (Volatility separations processes are based on the conversion of uranium and plutonium in reactor fuel to compounds which are separable from the fission products, and other constituents, by virtue of their differences in volatility and chemical stability.) The elements processed were highly enriched uranium-zirconium alloy fuels of the Shippingport (PWR) Seed Core I type. Product decontamination and recovery were excellent, and pilot plant operation was satisfactory. Although plutonium was not involved in these operations, cold engineering studies of volatility methods for recovery of plutonium continue to be encouraging. Advances in the development of volatility technology are of significance in that volatility methods represent the only known high decontamination alternates to aqueous methods, and that they hold a promising potential for reducing the cost of the reprocessing segment of reactor fuel cycles.

DEVELOPMENT AND IMPROVEMENT OF NUCLEAR REACTORS

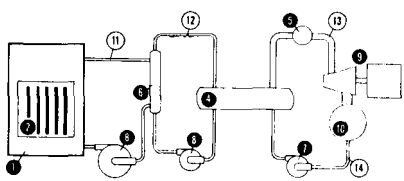
Twenty years ago the world's first crude experimental nuclear reactor went into operation under the University of Chicago's Stagg Field stands. Although this "crude pile of graphite and uranium" produced no usable power, it did prove that man could control a sustained nuclear fission chain reaction—the basis for today's "atomic era". Now, two decades later, reactor technology has advanced to a point where nuclear reactors can be designed in various ways to serve various purposes—such as (*a*) to produce electricity, process steam,



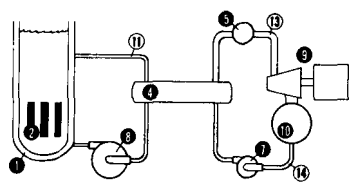
PRESSURIZED WATER



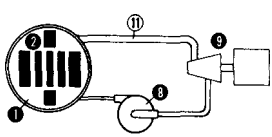
BOILING WATER



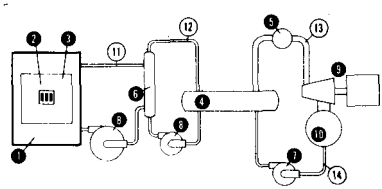
SODIUM GRAPHITE



ORGANIC COOLED AND MODERATED



HIGH TEMPERATURE GAS COOLED FOR GAS TURBINE



FAST BREEDER

FEATURES

1. REACTOR
2. CORE
3. BLANKET
4. BOILER
5. STEAM DRIER
6. INTERMEDIATE HEAT EXCHANGER
7. FEEDWATER PUMP
8. CIRCULATING PUMP
9. TURBOGENERATOR
10. CONDENSER
11. PRIMARY COOLANT
12. INTERMEDIATE COOLANT
13. STEAM
14. CONDENSATE
15. CIRCULATING FUEL

SIX BASIC REACTOR SYSTEMS

and space heat; (*b*) to propel vehicles; (*c*) to serve in specialized civilian and military applications; (*d*) to produce radioactive isotopes, artificial elements, and chemicals; (*e*) to serve as a basic or applied research tool; and (*f*) to train personnel in the fundamentals of reactor theory and reactor performance.

The programs of the Commission's Division of Reactor Development are directed primarily toward the development of reactors for the first three purposes—reactors for the other purposes are mentioned elsewhere in this report. A listing of all reactors built, being built, or planned in the United States will be found in Appendix 7.

Civilian Power Reactors Program

The Commission's civilian power reactors program has as its ultimate objective the development of a broad technology which can be used by the utility industry to achieve economic generation of electricity with nuclear power plants. In January 1955, the AEC determined that this ultimate objective could most expeditiously be achieved by its development of the basic technology of nuclear power reactors; by its constructing and operating reactor experiments and demonstration prototype nuclear power plants; and by its participating in varying degrees with private industry which would undertake reactor projects leading to the advancement of nuclear power technology.

Today, eight years since the Congress authorized initiation of this Power Demonstration Reactor Program (PDRP), there are 11 reactors in the civilian power reactors program which are Government-owned; there are 12 reactor projects in which the AEC and a public or cooperative utility share the costs; and there are seven atomic power plants which private industry has initiated based on Government-developed technology. All 30 facilities are considered as experimental or developmental plants rather than the large central power stations as envisioned for the future.

During 1962, four nuclear power plants built cooperatively by the AEC and utilities sustained their first atomic chain reactions and three privately owned plants reached the nuclear criticality stage.

Government-Owned Projects

Of the 11 Government-owned plants, 3 —Shippingport, the Sodium Reactor Experiment, and the Experimental Gas-Cooled Reactor—have some utility organization participation; 4—Experimental Breeder Reactors No. 1 and 2, Boiling Reactor Experiment No. 5, and the Experimental Boiling Water Reactor—are experimental reactors which will produce, or are producing, some electricity; and 4—Organic Moderated Reactor Experiment, Heavy Water Components

Test Reactor, Experimental Organic Cooled Reactor, and the Plutonium Recycle Test Reactor—are reactor experiments which do not provide for the generation of electricity. All are used for research and development purposes.

AEC-UTILITY PROJECTS

Shippingport Atomic Power Station

The Shippingport Atomic Power Station, which was the first large-scale nuclear power plant in the United States, has completed 5 years of operation with its pressurized water seed-and-blanket type reactor. Since initial operation in December 1957, this 60,000 electrical kilowatt (net) plant, operated for the AEC by the Duquesne Light Co., has supplied more than 1⅓ billion kilowatt-hours of electricity to users in the Pittsburgh, Pa., area.

The primary objective of Shippingport—which was built for the AEC by Westinghouse Electric Corp.—continues to be the advancement of the basic technology of pressurized water reactors. The reactor core and plant are heavily instrumented, and numerous tests have been conducted to evaluate the design and performance of the reactor, its fuel elements, and the reactor plant as a whole. The information from the design, development, fabrication, and testing of Shippingport has provided much of the technology and operating data now available on large water-cooled reactors for commercial generation of electrical power. To date, more than 1,600 technical reports on Shippingport developments have been distributed to the nuclear industry. In addition, training of reactor operators from both the United States and foreign countries is conducted at the Commission's Shippingport Reactor Supervisors Training School.

Design life surpassed. The Shippingport reactor core utilizes a relatively small seed of highly enriched uranium surrounded by a large blanket of Zircaloy-clad natural uranium oxide. Fissioning in the seed results in leakage of neutrons into the blanket where the neutrons either cause fission of the small amount of uranium 235 in the natural uranium or transforms uranium 238 to plutonium which, in turn, fissions. More than half the total power is produced in the natural uranium blanket. By periodically replacing the depleted seeds, the blanket fuel is depleted to high burnups and substantial amounts of power are obtained from the natural uranium.

The original natural uranium blanket was designed for a lifetime objective of 8,000 equivalent full power hours (EFPH). It is still operating after 21,000 EFPH. Three seeds have been depleted to date and on November 26, 1962, installation of the fourth seed was initiated. When the fourth seed is depleted, the blanket fuel will

have operated for over 27,000 EFPH. Evaluation of fuel elements removed for inspection during refuelings indicates that the blanket fuel is in good condition and can be safely depleted to higher burnups.

Core change in 1964. The fabrication of a second Shippingport core of advanced design is nearing completion. This new core, PWR Core 2, will have a power capability of 150,000 gross electrical kilowatts (the additional heat will not be used to generate electricity but will be dissipated through a heat sump), and will have a design lifetime of 20,000 EFPH. This will result in a design energy output 5.5 times than that of the present PWR Core 1. In addition to being an advanced design, PWR Core 2 will also have a new refueling arrangement which is expected to result in shorter refueling times; the core will utilize advanced type fuel elements consisting of oxide fuel plates clad with an improved zirconium alloy in both the seed and blanket; it will be more heavily instrumented than Core 1; and will use 20 instead of the 32 control rods and control drive mechanisms used in PWR Core 1. Installation of Core 2 and other plant modifications required to operate Core 2 at rated power will be initiated by the spring of 1964 after depletion of the fourth seed.

Sodium Reactor Experiment

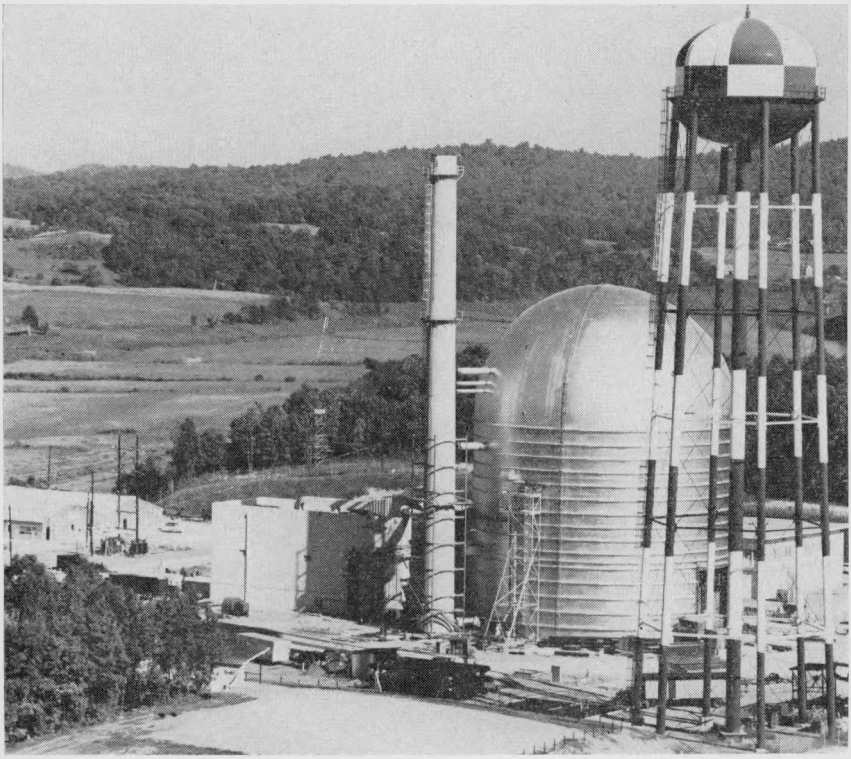
The Sodium Reactor Experiment (SRE) is located about 30 miles northwest of downtown Los Angeles. It is an experimental nuclear power plant built to develop technological data for designing, constructing, and operating full-scale atomic plants using liquid sodium as a coolant for the production of economic power. The AEC owns the nuclear portion of the plant, which is designed to produce 20,000 kilowatts of heat; the Southern California Edison Co. owns the steam-electric plant, which converts the reactor-produced heat into approximately 6,000 kilowatts of electricity (net). The reactor heat is furnished the utility company's facilities for generating electrical power intermittently, as the experimental program to develop improved fuel and fuel element configurations permits. This arrangement allows disposal of heat at a lower net cost than if the heat were dissipated or "dumped". The nuclear facility was built for the Commission, and is operated by Atomics International.

Early in April, the SRE was shut down in order that two defective moderator cans which prevented the reactor from attaining its design power level could be removed. Removal of the two units was an extremely intricate operation, and elaborate equipment had to be especially designed and fabricated so the reactor core could be opened for the cans to be removed and replaced, and yet not permit too much of the radioactivity from the hot core to escape.

The cans were successfully replaced, and the reactor resumed operation in August. By October 1962, the SRE, which first produced electricity on July 12, 1957, had generated 1,334,334 kilowatt-hours on its two cores for Southern California Edison customers.

Experimental Gas-Cooled Reactor

The slightly enriched uranium, gas-cooled, graphite-moderated Experimental Gas Cooled Reactor (EGCR), construction of which is under way at the Commission's Oak Ridge National Laboratory, is to be a combined experimental and power-producing facility. It is designed to permit experiments at various power levels and operating conditions with different types of experimental fuel elements and



Start-up in 1964. The Commission's Experimental Gas-Cooled Reactor (EGCR) is scheduled for completion in October 1964, at Oak Ridge, Tenn., at a cost of about $51 million. The EGCR will be the first civilian gas-cooled power reactor in the United States. In addition to generating about 22,300 electric kilowatts (net), the EGCR also will be used for experimental work for advancing the knowledge of gas-cooled systems, and for demonstrating their reliability. The facility will be operated for the Commission by the Tennessee Valley Authority (TVA). The plant is being built for the Commission by Kaiser Engineers and Allis-Chalmers.

plant components. It will also generate about 21,900 electrical kilowatts which will be used in the AEC's operations at Oak Ridge.

The Tennessee Valley Authority is providing some design and construction assistance to the AEC, will train personnel to operate the reactor, will assist in preoperational inspection and testing, and will operate the reactor for the Commission for a 5-year period. The principal nuclear contractors are Allis-Chalmers Manufacturing Co. and Kaiser Engineers.

Construction of the EGCR is expected to be complete by the fall of 1964, approximately 31 months later than its originally scheduled completion date. Slippage in completing the plant is due to design problems and problems in manufacturing some of the major nuclear components. Since the EGCR is the first gas-cooled power reactor to be constructed in the United States for central station power generation, no technical data or experience directly applicable to the project is available. Consequently, much of its basic technology has had to be developed, and many of its technical problems resolved, concurrently with the design and construction of the reactor.

AEC EXPERIMENTAL REACTORS

Experimental Breeder Reactor No. 1

The Experimental Breeder Reactor No. 1 (EBR–1), which in December 1951 produced the world's first electricity from atomic energy, is a liquid-metal-cooled fast reactor built and operated by the Argonne National Laboratory at the Commission's National Reactor Testing Station (NRTS) in Idaho. The reactor was designed (*a*) to demonstrate the fact that fast neutron systems can breed fissionable material, *i.e.*, that they can produce more fuel than they consume; and (*b*) to prove the feasibility of using high-temperature liquid-metal coolants in power producing reactors.

Both of these objectives were met during 4 years of EBR–1 operation on two core loadings. The reactor was then shut down in November 1955.

Reactor operation was restarted in November 1957 on a third core, called Mark III, to investigate the effects of mechanical, hydraulic, thermal, and nuclear variants on the stability of fast reactors.

During 1962, the EBR–1 was used to make power coefficient measurements, to test irradiate fuel elements of different compositions, to accumulate operating experience on plutonium fuel elements of the type which would make up a fourth EBR–1 core, and to train personnel who will supervise the operation of the full-scale Enrico Fermi fast breeder prototype plant.

Late in 1962, the third core fuel elements were unloaded and a plutonium-bearing fourth core, Mark IV, was installed in the EBR–1. On November 27, the reactor, with its Mark IV core, went critical.

Experimental Breeder Reactor No. 2 (EBR–2)

The EBR–2, designed by the Argonne National Laboratory (ANL) and being built at the NRTS, will be an experimental fast power reactor directed primarily at establishing the technical feasibility of fast breeder reactors for central station power plants. It will be able to generate 16,500 kilowatts of electric power.

It will be a completely integrated nuclear power plant incorporating the reactor, sodium boiler, and the fuel recycle processing plants. Spent fuel from the reactor will be reprocessed in a completely automated facility adjacent to the reactor, eliminating the need to ship fuel to processing plants many miles from the reactor site. Thus, when the EBR–2 goes into operation, it will usher in another "first" . . . the first attempt to recycle fuel in any reactor, to process spent fuel by pyrometallurgical methods, and to fabricate fuel elements by remote control.

A major step in the completion of EBR–2—loading of liquid sodium which will serve as the coolant—will begin in early 1963. Before this sodium loading can be accomplished, however, everything in the complex facility is undergoing a rigorous testing program. The value of this testing program is best illustrated by a concrete example: two large rotating plugs, which are part of the intricate mechanism for removing spent fuel elements from the EBR–2 and transferring them to the reprocessing plant, were found to be stuck during one of these "dry runs". Operations were immediately stopped and the trouble was located in a "freeze seal" designed to prevent the escape of radioactive gas to the atmosphere. Correction of the trouble required lifting a 50-ton part of the reactor a distance of about 23 feet and lifting it with such precision that 13 smaller components mounted vertically in the unit would not bind against the sides of openings through which they were pulled. In its report on the operation, ANL described the job as "something like pulling 13 pieces of thread through the eyes of 13 needles without allowing the threads to touch the inside of the needles' eyes." Had the operation not been successful, each of the 13 intricate components would have had to be disassembled piece by piece, and criticality of the reactor would have been greatly delayed.

It is now expected that criticality of the EBR–2 will be achieved in the spring of 1963.

Boiling Reactor Experiment No. 5 (BORAX-5)

BORAX–5 is the fifth in a series of experimental reactors built to investigate aspects of making nuclear power by boiling water with the heat produced by fissioning uranium atoms. BORAX–5 was designed and built by the Argonne National Laboratory to demonstrate the feasibility of making superheated steam by nuclear means. It has a 3,500 electrical kilowatt capability. The reactor achieved initial criticality—first became capable of sustaining a chain reaction—on February 9, 1962, at the NRTS near Idaho Falls, Idaho.

The principle of superheating steam is well known and widely employed in existing coal-fired power plants. In the nuclear superheat process, saturated steam—produced by one set of fuel elements in the core—is recirculated through a second set of fuel elements in the same core and superheated to still higher temperatures. Nuclear superheated steam should make more effective use of the heat produced by fissioning uranium atoms. This increased efficiency is expected to achieve a reduction in power costs.

Because of the necessity for understanding the characteristics of the reactor, BORAX–5 has been operated—since initial criticality—with only the boiling water core. Superheat experiments are expected to begin early in 1963.

During the experimental operation of BORAX–5, mechanical difficulty was encountered with the aluminum rivets used in the fuel assemblies. Nickel rivets were substituted for the original aluminum units, and after a delay of three weeks the reactor was back in operation.

BORAX–5 is designed to produce 40,000 kilowatts of thermal power, Steam produced by the reactor can be used to drive a 3,500 kilowatt turbine-generator system for the production of electricity.

Experimental Boiling Water Reactor (EBWR)

One of the nation's pioneer atomic power plants, the EBWR at Argonne National Laboratory has completed an experimental program aimed at determining the maximum power which could be safely extracted from it, and is currently being prepared for a new experimental role.

EBWR, which has undergone major modification in the past three years, began the approach to higher power operation in August 1962. On September 7, it reached an operating power level of 62,000 kilowatts of heat, and on November 15, it achieved a power level of 100,400 thermal kilowatts—more than five times its original design capacity of 20,000 kilowatts of heat.

Operation of the EBWR continued at this new high power level until the end of the year. The reactor was then placed in standby condition until fuel is available for its new assignment, that of helping develop the potential of plutonium as a nuclear fuel.

In this new project—a joint effort of ANL and the AEC's Hanford Laboratories at Richland, Wash.—the reactor will be operated with a combined loading of plutonium and uranium nuclear fuel. As currently proposed, the loading of fuel for this operation would consist of a central zone of fuel assemblies—manufactured at Hanford—containing plutonium oxide and uranium oxide. Surrounding these assemblies would be fuel assemblies containing uranium oxide enriched in U–235. Startup of experimental operation in this program is expected to begin early in 1964.

AEC REACTOR EXPERIMENTS

Organic Moderated Reactor Experiment (OMRE)

The OMRE, located at the National Reactor Testing Station, was constructed and is operated for the AEC by Atomics International. It is not a prototype power reactor; rather, it is a facility with a primary objective of demonstrating the technical and economic feasibility of using organic compounds as reactor moderating and cooling materials. The use of organic compounds, such as diphenyl, has several potential advantages, among which are low induced radioactivity, low corrosion of fuel elements, and high boiling point which makes relatively high temperature systems possible.

The OMRE has been in operation since September 1957. During this period, coolant technology, materials, design, and evaluation studies related to organic cooled experimental and power reactors have been pursued.

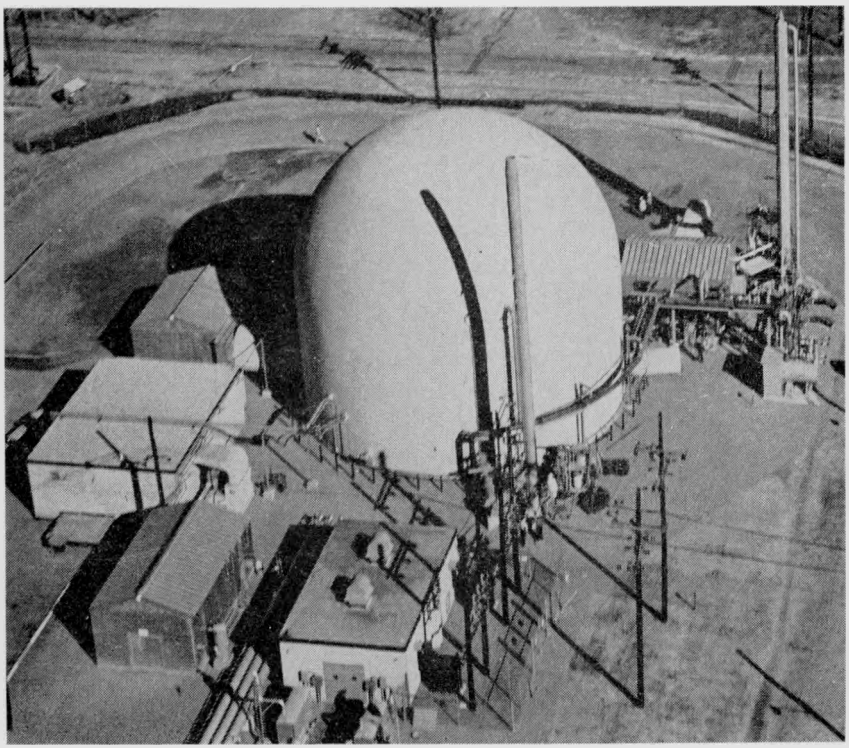
During 1962, the OMRE has continued to operate on the third core loading with success toward resolving the fuel element surface fouling problem. The initial third core (Core III–A) operation was concluded late in 1961 after 282 megawatt days. Examination of fuel elements, removed from Core III–A showed very little film formation except for certain areas of two test elements which were maldesigned.

In the interim between Core III–A and the present Core III–B, the OMRE's coolant purification system was further improved, and two new test elements of the aluminum-clad uranium alloy type, and four of the APM (aluminum powder metallurgy) clad uranium dioxide type were added to the core. Core III–B has successfully operated at its expected peak thermal power of 4.5 megawatts for a cumulative

total of two megawatt days. Operation with Core III–B will continue into next year.

Heavy Water Components Test Reactor (HWCTR)

The HWCTR at the Commission's Savannah River Plant is an experimental pressurized heavy water unit designed to permit testing of fuel elements and critical components, and to provide other information on which to establish the basis for the design of a full-scale heavy water power reactor. Construction and pre-startup tests were completed early in the year, and the reactor—designed and built for the AEC by the duPont Co.—attained criticality on March 3. It will not be used to produce electricity.



HWCTR Facility. The Heavy Water Components Test Reactor (HWCTR), an experimental pressurized heavy water reactor, designed and built by the E. I. du Pont de Nemours Co. for the AEC at its Savannah River Plant, Aiken, S.C., became operational on March 3, 1962. The 61 thermal megawatt facility permits simultaneous test irradiation of up to 12 full-sized natural uranium fuel elements at power ratings and exposures encountered in full-scale civilian power reactors using heavy water as a coolant. No electricity is being generated at the plant, the heat being dissipated to the atmosphere through a light water secondary system.

During the conduct of low-power physics tests in April, the formation of helium voids in the moderator was discovered which influenced the reactivity of the reactor. The problem was corrected by modifications to the reactor vessel.

The reactor was operated at a power of up to 24 thermal megawatts for four weeks during August and September. This preliminary run was made without test fuels of natural uranium, and served to measure the performance of heat removal systems.

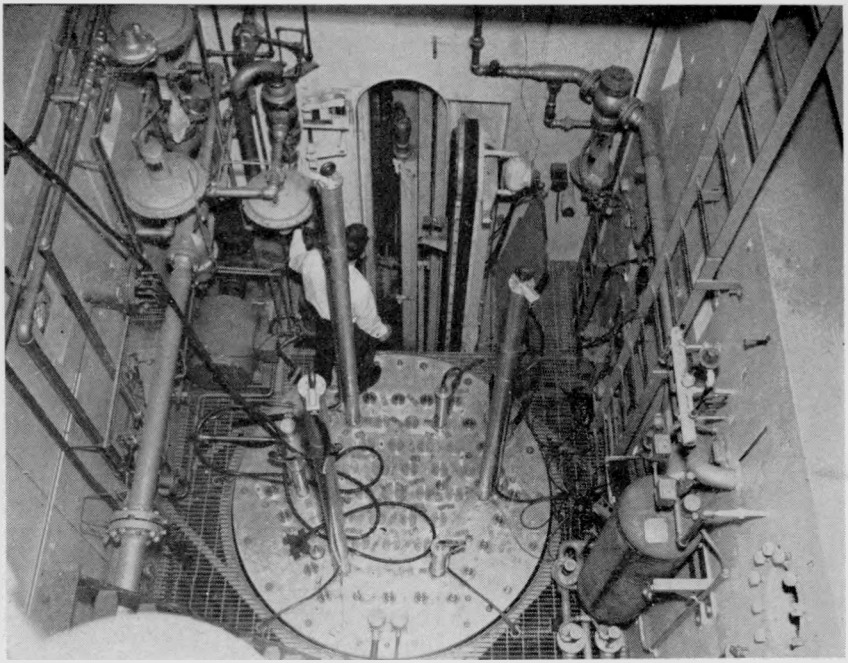
Operation with test fuels of natural uranium metal and uranium oxide were begun in October following a program of minor modifications and startup evaluation. The test program of the reactor will include long-term irradiation of natural or slightly enriched fuel elements in tubular form of both metal and oxide composition. A set of fuel bundles for the CANDU reactor will also be tested in this program as part of the AEC-Canadian Cooperative Program on Power Reactor Development.

Experimental Organic Cooled Reactor (EOCR)

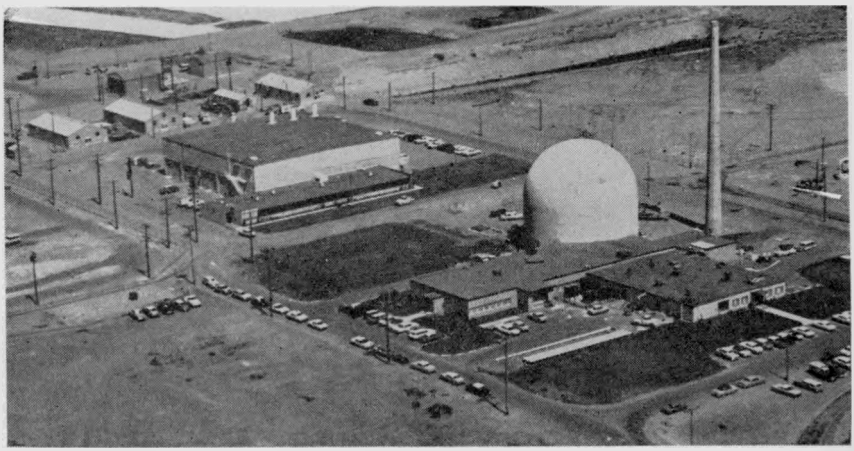
The EOCR, construction of which was completed in November, is located at the AEC's NRTS in Idaho. Construction contractor was C. F. Braun & Co., Alhambra, Calif.; the Fluor Corp., of Los Angeles provided architect-engineering design services; the Phillips Petroleum Co. prepared the conceptual design for the 20,000–40,000 thermal kilowatt facility.

The Experimental Organic Cooled Reactor is a flexible facility which was to have been used for experiments aimed at developing economically competitive organic cooled and moderated reactors. Plans were that two loops would be installed in the reactor prior to power operation which was expected to begin during the fall of 1963. One loop, the "fuel technology loop," was to be used to determine the characteristics and properties of various fuels and fuel configurations proposed for organic power reactors. The second—the "coolant technology loop"—was to be used for in-pile testing of both new and existing organic coolants and improved coolant processing systems.

Early in December, the Commission announced it was curtailing its organic cooled and moderated reactor activities because the organic reactor concept does not hold early promise of significantly improving nuclear powerplant performance above that already achieved by other reactor concepts. Accordingly, installation of the two test loops in the EOCR has been deferred, and upon completion of system testing, which has been in progress since construction of the facility was completed, the EOCR will be put into a standby status pending a decision on its future use.



Plutonium Test Facility. Construction of the Plutonium Recycle Critical Facility adjacent to the Plutonium Recycle Test Reactor at Hanford, Wash., was completed in April 1962. Photo *above* shows the top of the critical facility which will be covered by several feet of water when operational. The critical facility permits measurement of the changes in reactivity of individual PRTR fuel elements after successive increments of irradiation in the PRTR. It will also be used to conduct critical experiments using both light water and heavy water as moderators. The Commission's Plutonium Recycle Test Reactor (photo *below*) experiment is being used to demonstrate the feasibility of a power reactor concept in which plutonium would be recycled as an alternative or supplement to uranium fuel in thermal heterogeneous reactor systems. The work is being done by General Electric for the AEC.



Plutonium Recycle Test Reactor (PRTR)

The PRTR is an essential research tool in the Commission's Plutonium recycle program. The plutonium recycle program, which was undertaken by Hanford Laboratories of the General Electric Co. in 1956 at the request of the AEC, is aimed at developing the technology and techniques for using recycled plutonium as an alternate for uranium 235 as a fuel in power reactors.

Plutonium is a byproduct of almost all nuclear power reactors. If this unburned plutonium generated in power reactors can be recovered, reprocessed, and added to natural or depleted uranium or thorium, a reactor system capable of operating on a fuel cycle independent of enriched uranium feed may be made possible. A system capable of operating on recycled plutonium would not only contribute to the conservation of resources of fissionable material, but also may lower reactor operating costs.

There are many technical problems associated with the use of plutonium as a power reactor fuel—plutonium is extremely toxic; its physics characteristics are different from, and more complicated than, those of uranium 235; and there is a complete lack of experience in its use in commercial applications. There is also a question of the economic feasibility of recycling plutonium. Reactor physics, chemical reprocessing, and plutonium fuel element technology all have a direct bearing on the competitive economic position of plutonium. Throughout 1962, the PRTR was used for continuing its investigations in all of these areas.

Cooperative Projects

There are 12 atomic power projects in which the Commission and a public or private utility share the costs. Although the arrangements vary somewhat, there are basically only two types of AEC-utility financing methods which have been used in the Commission's Power Demonstration Reactor Program—the "second round" invitation of September 1955, and the "third round" invitation of January 1957. These two invitations were much more specific in the terms under which cooperative projects would be undertaken than was the "first round" invitation of January 1955.

"First-Round" Projects

As a result of the Commission's first invitation to industry to participate on a cooperative basis in the application and development of nuclear technology to the generation of electricity, three atomic power

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plant projects were undertaken—Hallam, Yankee, and Fermi. Because the first invitation was general in nature, the cooperative financing arrangements for each of the three projects is slightly different but they do include the basic cooperative arrangements which became more definitive in the two later invitations.

Hallam Nuclear Power Facility

The 75,000 electrical kilowatt Hallam Nuclear Power Facility achieved criticality on August 25, 1962. Because of the reactor's characteristics, however, the plant will not be operated at full power until after mid-1963. The Consumers Public Power District of Nebraska is the participating utility with the AEC in this project, located on a site 19 miles south of Lincoln. It is the first nuclear power facility to be operated by a consumer-owned utility.

Under the terms of the Commission's agreement with Consumers, the AEC, with specific assistance from Consumers, financed construction of the nuclear portion of the plant, bore the major portion of the preconstruction research and development costs, and will bear post-construction research and development costs. Consumers provided the site, the turbine-generator facilities, contributed to the costs of construction of the nuclear portion of the plant, and will operate the entire plant for 5 years for the AEC. Prime nuclear contractor for the project was Atomics International.

Before being taken to full design power, a series of experiments and operations are to be performed for a period of approximately 18 months at levels not in excess of 15 percent of full power. During this experimental period, anticipated plant nuclear characteristics will be verified, the operational safety and integrity of the plant systems under nuclear conditions will be demonstrated, personnel will be provided with operational training and experience, and equipment specifications will be confirmed.

These low power operational tests are deemed necessary because the Hallam facility, although based on the design of the Sodium Reactor Experiment at Santa Susana, Calif., is the first large-scale sodium-cooled, graphite-moderated reactor developed for the production of commercial power. And although sodium has long been recognized as a potentially advantageous reactor coolant because of its high thermal conductivity, it also has the disadvantage of having a high chemical reactivity. During the low power test runs, the safety features designed into the reactor to eliminate the possibility of chemical reactions will be verified. AEC authorization for further ascent in power levels above 15 percent of full power will be dependent upon an evalu-



Fuel Handler. Photo shows the 50-foot high, 250-ton fuel handling machine being moved into position over the reactor at the new Hallam Nuclear Power Facility near Lincoln, Nebr. The machine is used to exchange new and spent fuel elements in the sodium-graphite reactor which is located beneath the circular control rod mechanism housing (*bottom, center of photo*). The machine was developed for the Commission by Atomics International and is capable of handling 40-foot long reactor components. The "Mast" is heavily shielded to protect plant personnel from the high degree of radiation given off by fuel elements withdrawn from the reactor for transfer to storage cells.

ation by the AEC regulatory staff and the Advisory Committee on Reactor Safeguards of the experimental information obtained in connection with the low power operations.

It is anticipated that the low power experiments will be completed by mid-1963, and that soon thereafter the steam produced from the heat of the reactor can be piped to Consumers' adjacent turbine-generator equipment to produce sufficient electricity to supply a community of about 100,000 people.

Yankee Nuclear Power Station

The contract which the AEC entered into with the Yankee Atomic Electric Co. of Boston, Mass., was the first to be concluded under the AEC's Power Demonstration Reactor Program. The Yankee Atomic Electric Co., an association of 10 New England utilities, financed the entire capital cost of the Rowe, Mass., nuclear power project; the AEC provided research and development assistance, and waived for a period of 5 years its normal charge for the use of special nuclear material to fuel the reactor.

The Yankee Station achieved initial criticality in August 1960; reached its full initial licensed power of 110,000 electrical kilowatts in January 1961; was licensed to increase its power level from 110,000 to 141,000 net electrical kilowatts in June 1961; began operation on a fully commercial basis in July 1961; had, by January 12, 1962, achieved a total output of one billion kilowatt-hours; and by February of 1962, had produced more electric power than any other nuclear power station in the United States.

The first core of the light water-cooled and -moderated pressurized water reactor—which on January 15, 1962, had reached its so-called design lifetime—was actually not removed from the reactor until May 18. By the time of its removal, Core I operation had resulted in the generation of 1.3 billion kilowatt-hours of electricity at a company-estimated cost of slightly under 10 mills per kilowatt-hour. Original estimates were that the first core would provide 880 million kilowatts at an estimated cost of 10 to 12 mills per kilowatt-hours.

Inasmuch as the Yankee reactor was the first to use fuel rods consisting of uranium dioxide pellets enclosed in cylindrical stainless steel tubes, the AEC contracted with the Yankee Electric Co. for the reinsertion of two Core I fuel assemblies into its reactor with the Core II assemblies so their integrity after extended burnup could be determined. At the same time, Westinghouse Electric Corp.—which built the reactor—was selected to analyze and evaluate for the AEC the Yankee spent first core to determine if and how its design might be improved. Improved core design methods will reduce reactor costs and thus are expected to materially contribute to the achievement of economic nuclear power.

On June 6, the Yankee Atomic Electric Co. was awarded the electric utility industry's highest honor—the Edison Award. Yankee was cited "for the completion well ahead of schedule, and at a capital cost 23 percent below estimate, of a 150,000-kilowatt power plant utilizing nuclear energy; producing over 1 billion kilowatt-hours at a fuel cost of 2.8 mills per kwh, compared to an average fuel cost of 4.2 mills in the territory served; financing the construction with private funds of 10 cooperating companies serving the region; having

the nuclear steam generator available for load 96 percent of the time with the plant producing electricity at a 70 percent load factor; developing a staff of well-trained personnel who did the fuel loading; and achieving an overall result that caused three of the cooperating utilities to announce their intention to build a 400,000-kilowatt nuclear station."

The second Yankee core was installed into the reactor, went critical in September, and achieved full power 10 days later. The second core is identical to the first in both mechanical design and fuel enrichment, but is expected by Yankee to produce approximately 10 percent more power than the first core.

Fermi Plant

The 60,900 electrical kilowatt Enrico Fermi Atomic Power Plant being built at Lagoona Beach, near Monroe, Mich., by the Power Reactor Development Co. of Detroit, is now scheduled to be completed early in 1963. It will be the first plant of its kind.

During nonnuclear preoperational tests, several engineering problems appeared which required correction. The synthetic graphite neutron reflector, or shield, around the core tank deteriorated at high temperatures, and its replacement was required. Graphite repair work has been performed on a 24-hour per day, 7-day week basis since May 1962, however, and was scheduled to be completed in December.

During tests, it was also found that high temperature inert gas reached the steam generators containing residue from precleaning which was high in chloride content. The resulting stress chloride corrosion to tubing required replacement of a portion of the tubing in the steam generators. This work has recently been completed, and the steam generators are now ready to be filled with sodium.

The fuel handling mechanisms and other core components related to fuel holddown were damaged during high temperature sodium testing. These components had to be repaired or replaced with components containing features designed to preclude further malfunction problems. This repair work proceeded on an over-time basis, and was completed in November.

The Fermi reactor will be a fast-neutron breeder-type in which neutron bombardment creates, or breeds, new fissionable material as the basic fuel is consumed. In this type of power reactor, the neutrons which split the atoms of the fissionable uranium 235 fuel in the reactor core—thus releasing additional neutrons and energy in the form of heat—are "fast" neutrons that travel at a velocity of about 10,000 miles per second, much faster than neutrons in ordinary reactors. When these neutrons escape the core of the reactor, which is

composed of fissionable U–235, they convert the atoms in a surrounding blanket of nonfissionable uranium 238 into fissionable plutonium. Thus, this fast neutron type reactor will not only generate energy to produce electric power, but it will also create new reactor fuel.

"SECOND-ROUND" TYPE ARRANGEMENTS

By one method, known as the "second-round" type arrangement, the Commission builds and owns the nuclear steam supply system, conducts all necessary nuclear research and development work, and defrays all costs of operating the nuclear portion of the plant. The participating utility—which must be a cooperative or publicly-owned organization—provides the plant site and furnishes the conventional nonnuclear power plant facilities, operates the plant under contract with the AEC, purchases from the AEC the steam produced by the reactor, and has the option to buy the reactor. The facilities undertaken under second-round type terms are the Elk River, Piqua, BONUS, and LaCrosse projects.

One of these projects, the Elk River Reactor, reached initial criticality this year. The Piqua Nuclear Power Facility, and the Boiling Nuclear Superheat Reactor (BONUS) project being carried out jointly by the AEC and the Puerto Rico Water Resources Authority, are expected to reach criticality in 1963. The Dairyland Power Cooperative-AEC LaCrosse Boiling Water Reactor project near Genoa, Wis., was initiated during 1962, and its construction is scheduled for completion in May 1965.

Elk River Reactor

The Elk River reactor achieved criticality on November 19, almost 2 years later than had originally been planned.

Site construction for the 22,000 net electrical kilowatt reactor project was started in Elk River, Minn., during August 1958. At that time, completion was scheduled for October 1960, and initial criticality for December 1960. However, a steel strike called in September of that year slowed equipment deliveries and set the criticality schedule back 2 months. Subsequent strikes in component vendors' plants, and difficulties experienced in fabricating fuel elements, further delayed the schedule. Then, in mid-1961 hairline cracks were detected in the stainless steel cladding inside the pressure vessel.

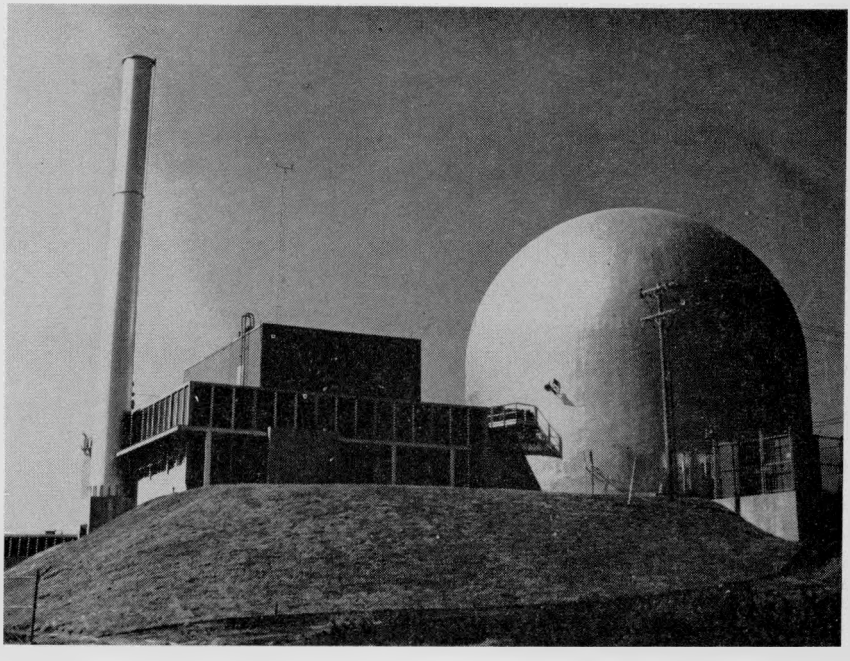
Repairs were made to, and extensive studies and exhaustive tests were performed on, the vessel, and in June 1962, a determination was made that the vessel could be safely used for its intended service for a period not to exceed 5 years. Operation beyond this period will be dependent upon AEC review of reactor operations during the initial

5-year period. Following public hearings, authorization to operate the reactor was issued early in November, and criticality was attained on November 19.

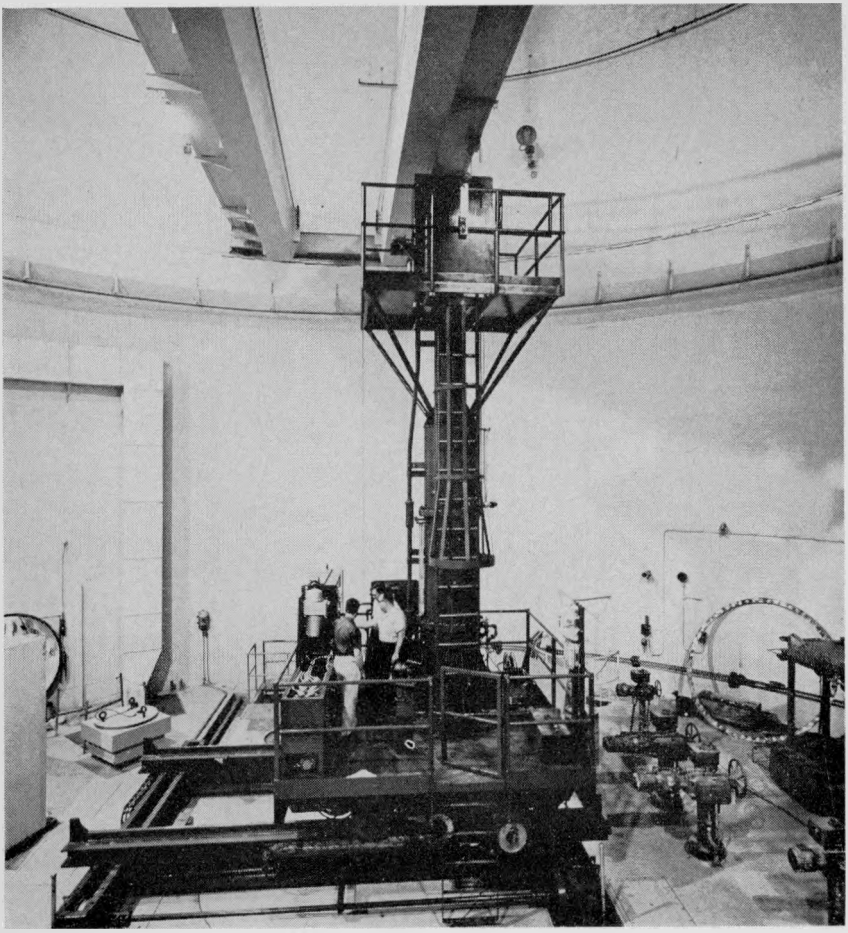
The reactor was built for the AEC by the Allis-Chalmers Manufacturing Co. and will be operated for the AEC by the Rural Cooperative Power Association of Elk River. In addition to generating electricity for Rural Cooperative customers, the reactor will provide physics, heat transfer, irradiation, and performance data on urania-thoria fuel. It will also provide cost data on a small plant using an indirect, natural circulation, boiling water reactor coupled with a separate coal-fired superheater.

Piqua Nuclear Power Facility

The City of Piqua, Ohio—a community of approximately 20,000 people, located about 21 miles from the metropolitan area of Dayton—is the only municipality participating with the Commission in building a nuclear power plant.



Piqua Plant. The 11,400 electrical kilowatt Piqua, Ohio, Nuclear Power Facility showing the dome shaped building (right) that houses the organic cooled nuclear reactor, and the administration and process building (left). The nuclear plant, which is expected to be operated in early 1963, was built by Atomics International, a division of North American Aviation, Inc., for the Atomic Energy Commission. It will be operated by the City of Piqua, marking the first time a municipal power system has operated a nuclear power system.



Inside Piqua's Dome. Once a nuclear power reactor has been in operation, its fuel rods become highly radioactive (irradiated) and must be handled with extreme care. Photo shows the movable fuel rod loading and unloading machine developed for use with the Piqua, Ohio, power reactor. When being moved into or out of the reactor, the fuel rods are enclosed in the shielded "stack". The top of the reactor, which is below the floor level, is hidden from view by the machine's base structure.

The Piqua Nuclear Power Facility was developed to demonstrate the technical and economic feasibility of integrating an organic power reactor into an existing city-owned electric utility system. Construction of the 11,400 net electrical kilowatt reactor, moderated and cooled by a high boiling point hydrocarbon and fueled by slightly enriched uranium, began during July 1959. At that time it was forecast that the reactor would reach initial criticality in April 1961 and full power operation in September 1961.

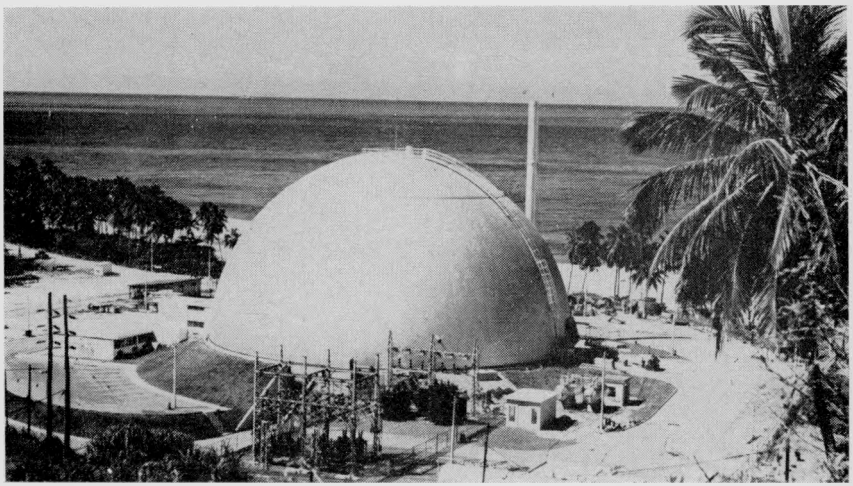
General construction difficulties, strikes which delayed the installation of equipment, a minor fire, and certain defects in the heating and ventilating system which were revealed during preoperational testing—all combined to delay the schedule.

Preoperational testing is now progressing satisfactorily, however, and the facility is expected to attain criticality early in 1963. Following a period during which the reactor will be completely tested, it will be turned over to the City of Piqua for operation, probably by mid-1963. The reactor was built by Atomics International.

Boiling Nuclear Superheat Reactor (BONUS)

Criticality of the Boiling Nuclear Superheat Reactor project being carried out jointly by the AEC and the Puerto Rico Water Resources Authority is now scheduled for late 1963 rather than late 1962. The delay in criticality is due primarily to a change in the scheduled delivery date for the reactor pressure vessel due, in large part, to unforeseen difficulties encountered in fabricating this unique and complicated component. The reactor will have a centrally located boiling core region and a peripherally located superheater region.

The reactor is being constructed on a site about 2 miles northwest of the community of Rincon, P.R. It is of the boiling water type, will



First in Tropics. The BONUS plant is being built near Rincon, Puerto Rico, as a joint project of the AEC and the Puerto Rico Water Resources Authority. BONUS—for Boiling Water Nuclear Superheat—will produce 16,300 electric kilowatts (net), and the completion of construction by Maxon Construction Co. is scheduled for July 1963. The BONUS plant, first power reactor to be built in the tropics, has as its primary purpose demonstrating the advantages of using water reactors producing superheated steam for production of electricity.

use uranium dioxide as fuel, and will produce nuclear superheated steam within the reactor core for the generation of 16,300 electrical kilowatts.

La Crosse Boiling Water Reactor (LACBWR)

Early in June of 1962, the AEC signed contracts with the Dairyland Power Cooperative of LaCrosse, Wis., and the Allis-Chalmers Manufacturing Co., for a 50,000 net electrical kilowatt nuclear power plant to be built near Genoa, Wis. The plant is to be powered by a single-cycle, forced-circulation, light water cooled and moderated boiling water reactor employing internal steam separation.

This project, designated the LaCrosse Boiling Water Reactor, stems from an unsolicited proposal submitted to the AEC by the Dairyland Cooperative in 1961.

Under the terms of the contracts, Allis-Chalmers will design, construct, startup, and test operate the reactor for the Commission, and will train Dairyland personnel to operate and maintain the reactor plant. Dairyland will furnish the plant site, the turbo-generating equipment, operate the plant for 10 years, and purchase the steam produced by the reactor.

The LACBWR project is expected to provide information on the use of internal steam separation and low alloy steam piping materials, and is intended to demonstrate the economic feasibility of an intermediate size boiling water reactor.

Process Heat Plant Proposal

In March, the Packaging Corp. of America expressed interest in participating, in concert with Atomics International and Gilbert Associates, in the construction and operation of a 160,000-thermal kilowatt organic cooled combined electrical power and process heat reactor plant which would supply electricity and steam for their Filer City, Mich., pulp and paper mill. The Organic Power and Heat Industrial Reactor (OPHIR) project was proposed to be undertaken essentially under second-round Power Demonstration Reactor Program terms. The Packaging Corp. was informed by the Commission in May that a formal, unsolicited joint proposal such as they had proposed would be given serious Commission consideration.

In August, Atomics International submitted a proposal to the AEC covering the development, design, and construction phase of the OPHIR proposal. Since the terms of their proposal were not acceptable to the AEC, funds obligated for the OPHIR project were made available by the Commission to meet construction cost over-runs in other programs.

On November 21, the Commission was informed by the Packaging Corp. that it had decided not to submit a proposal to the AEC primarily because the time schedule for the project did not fit into their steam plant expansion plans.

"THIRD-ROUND" TYPE ARRANGEMENTS

The other basic type of cooperative arrangement—the third-round type—requires that the participatiing utilities, which may be public or private organizations, supply the plant site, build—and thus own—and operate the entire facility. The AEC pays for part of the nuclear research and development work, and waives fuel use charges for a specific time. (Under the latest third-round invitation, discussed later, design assistance was added.) The projects undertaken under third-round type arrangements are the Pathfinder, Big Rock Point, Carolinas-Virginia, Peach Bottom, and Southern California Edison projects.

Of these five third-round type projects, Big Rock Point began operating for the first time during 1962; Carolinas-Virginia and Pathfinder are not now scheduled for operation until 1963; the Peach Bottom project is to be completed by 1964; and an application to construct the Southern California Edison plant has not yet been received by the Commission.

Big Rock Point

The Consumers Power Co. of Michigan plant located at Big Rock Point on upper Lake Michigan—in Charlevoix County—first became capable of sustaining a chain reaction (criticality) on September 27, 1962. The $27 million, 47,800 electrical kilowatt plant was within its original cost estimates and on schedule for criticality date. The nuclear portion contractor was the General Electric Co.

Since achieving criticality, the plant has been undergoing a series of tests at various reactor power levels and under various pressures. Full power operation is expected early in 1963.

The Big Rock Point plant is to be used primarily to conduct a 4½-year research and development program sponsored by the AEC. The research, which will be programmed so there will be a minimum of interruption to the generation of electricity, consists of the development and testing of advanced fuel elements and cores aimed at achieving high power density (high power generation per unit volume of reactor core), long life, and low fabrication cost. This work will augment research being performed with the Vallecitos Boiling Water Reactor.

After completion of the research and development program, Consumers Power Co. will use the boiling water reactor plant for commercial power production. The plant's initial electrical generating capacity is less than 50,000 kilowatts, but during the research and development program it is expected that the electrical generating output of the plant will be increased to 75,000 kilowatts.

Pathfinder

Criticality of the Pathfinder plant of the Northern States Power Co. of Minneapolis, which is to have an electrical capacity of 62,000 kilowatts, is not expected now until late 1963. The plant near Sioux Falls, S. Dak., was originally planned for mid-1962 operation.

Saturated steam, formed in the boiling region of the reactor will, instead of being routed directly to the turbine-generator for conversion to electrical energy, be recirculated to flow through a superheater, located within the reactor core, and be converted to superheated (dry) steam before going to the turbine. The higher temperature of superheated steam will result in increased plant efficiency. The reactor will be fueled with slightly enriched uranium and the superheater will be fueled with highly enriched uranium.

Superheater difficulties. Difficulties have been encountered by all the nuclear superheat reactor projects—Pathfinder, BONUS, and the Commission's experimental Borax-5—in finding a suitable material with which to clad superheater fuel elements. Fuel elements clad with one type of stainless steel failed during tests due to chloride stress corrosion—a deposition of too much chloride on superheater cladding surfaces because of the elimination of any drying within the superheater. This chloride concentration corrodes and erodes the clad and causes wide swings in temperature within the reactor.

Cladding study. In an effort to resolve the superheater cladding problem, the AEC has contracted with the General Electric Co. to conduct a long-range superheat fuel development program. Work under the contract, to be performed in the Empire States Atomic Development Associates—Vallecitos Experimental Superheat Reactor near Pleasanton, Calif., will include the design, development, and fabrication of fuel to be tested; pre- and post-irradiation examination of fuel elements; analysis of defected test elements; and testing of a variety of cladding materials, including several types of stainless steel, Inconel, and Hastelloy-X.

Carolinas-Virginia

Construction of the Carolinas-Virginia Nuclear Power Associates, Inc. (CVNPA) facility was completed, and startup of the reactor is planned early in February 1963.



Unique Site. Overall view of the Parr, S.C., site of the Carolinas-Virginia Nuclear Power Associates new nuclear power plant on the *left* with the South Carolina Electric & Gas Co. steam generating plant in the foreground at *right*, and the small, but still active hydro-electric plant on the Broad River in *upper center*. This is believed to be the only site in the world which has hydro, fossil fuel (coal), and nuclear power plants all capable of producing electricity at the same time. The Carolinas-Virginia Tube Reactor (CVTR) was designed and built by Westinghouse Electric Corp. The steam from the reactor will be passed through an oil-fired superheater and then piped into a turbine in the existing coal-fired plant.

The pressure tube reactor, being fabricated by Westinghouse Electric Corp., will be a first of its kind. The plant is located at Parr, S.C., about 25 airline miles northwest of Columbia. The CVNPA plant uses heavy water as both coolant and moderator, and is unusual in that it uses U-shaped pressure tubes installed in a relatively simple and low-pressure tank instead of a large heavy steel pressure vessel for housing the core and its structural support. Each of the 36 pressure tubes contains uranium dioxide fuel. Heavy water will be pumped into these tubes to carry off the heat generated in the fission process. Steam from the nuclear portion of the plant will be fed to an oil-fired superheater where its temperature will be raised to meet the operating conditions of the existing turbine in an adjacent coal-fired power plant.

Although the reactor has an initial output of approximately 15,000 electrical kilowatts, eventual operation at a power level equivalent to 17,000 electrical kilowatts is planned.

It is anticipated that a great deal will be learned about the nuclear, mechanical, and thermal behavior of this reactor which can be applied to a full-scale power reactor.

Peach Bottom

Construction began during the spring of 1962, in Peach Bottom Township, Pa., on the 40,000 electrical kilowatt high temperature gas-cooled reactor which will serve in proving the practicality of a promising concept for gas-cooled reactors. Although the Peach Bottom plant is being built primarily as a prototype for a larger central power generating station, it will be the first civilian gas-cooled reactor capable of producing such high outlet temperatures (1,380° F.), and, therefore, a high overall plant efficiency. In addition to high temperatures, this concept offers long fuel life by utilizing thorium as part of the fuel.

The fuel is an advanced concept consisting of pyrographite-coated particles of thorium-uranium carbide, dispersed in a graphite matrix, and contained in a graphite sleeve. The pyrolitic coating in effect serves to clad each fuel particle. Provision is made to vent these fuel elements to minimize the fission product content of the helium coolant.

The Peach Bottom plant will be owned and operated by Philadelphia Electric Co. in conjunction with a group of 52 other electrical utilities interested in this concept. The AEC provided research and development assistance in establishing technology for this reactor, and will waive fuel use charges for the first 5 years of operation. The General Atomic Division of General Dynamics Corp. is the principal nuclear contractor.

Completion of Peach Bottom construction is presently scheduled for mid-summer of 1964, with operation to follow some few months later.

Southern California Edison Coast Nuclear Station

At the end of 1962, the siting difficulties of Southern California Edison's proposed pressurized water reactor plant appeared to be nearing an end.

In April of 1961, an unsolicited proposal submitted jointly by the Southern California Edison Co. and the Westinghouse Electric Corp. sought AEC research and development support for a 355,000 electrical kilowatt pressurized water reactor plant which the utility planned to

build and operate under the Commission's Power Demonstration Reactor Program. The joint proposal was accepted by the AEC as a basis for contract negotiations, contingent upon Southern California's ability to obtain a suitable plant site.

The site where the utility proposed building its Coast Nuclear Station was within the Marine Corps reservation at Camp Pendleton in Southern California. Early in 1962, the Navy advised the utility that because of national defense considerations it could not act favorably upon its request for use of the site. Consequently, late in June, Westinghouse, Southern California Edison, and the AEC mutually agreed that contract negotiations for the project would be terminated if a suitable site were not located by September 15.

Prior to September 15, the Navy granted Southern California Edison permission to use a section of the Camp Pendleton reservation different from that on which the utility had originally proposed building its plant. The AEC agreed to extend from September 15 to November 15—and subsequently to early January 1963—the time in which the utility could locate a site in order that they might make test borings at the newly released Navy site. As soon as the site situation is resolved, contract negotiations will be initiated.

NEW INVITATION

On August 23, 1962, the Commission invited proposals from industry to participate in the design, construction, and operation of large-scale—at least 400,000 gross electrical kilowatts—nuclear power plants, incorporating reactors of proven design, under modified third-round type arrangements.

Under the terms of this invitation, which was extended to investor-owned, cooperatively owned, and consumer-owned electric utilities, the AEC will provide financial assistance of $10–15 million toward the cost of nuclear research and development work, preliminary and detailed design work, plus fuel and heavy water use charges. The participant must provide a suitable site, construct the plant, bear all other costs related to the project, and operate the plant for a period of 5 years after initial criticality. The invitation is applicable only to new projects; it will not be made retroactive for projects already under, or well-advanced toward, construction.

This is the first Power Demonstration Reactor Program invitation issued by the AEC in which the AEC has offered to make design assistance available to privately owned utilities. Proposals in response to this invitation are to be submitted to the AEC by late January, 1963, with selection of those acceptable as a basis for contract negotiation to be made by late March 1963.

LARGE-SCALE PWR STUDY

Late in June, the Commission authorized its New York Operations Office to negotiate a contract with the Westinghouse Electric Corp. for the conduct of a joint 9-month study with the AEC to determine the technical and economic feasibility of building a pressurized water reactor (PWR) scaled up to 1,000,000 electrical kilowatts.

The first phase of the three-phase study will define the research and development necessary to build a million electrical kilowatt plant with a single, closed cycle reactor. Phase two will consist of a review of the limitations of typical sites in densely populated areas where such plants would be needed, and the third phase will include the preliminary design of the plant for a hypothetical site and the preparation of estimates on capital, fuel, operating, and maintenance costs.

If found to be feasible, a plant of this size could be in operation by 1970 since, as a scaled-up version of the Shippingport reactor concept, no prototype development would be required.

Private Projects

There are seven atomic power plants which private industry has initiated, based on Government-developed technology. Four of these seven projects are now in operation.

During 1962, the Consolidated Edison Co. reactor at Indian Point, N.Y. and the Saxton Nuclear Experimental Corp. project at Saxton, Pa. became operational. These two new plants, together with the Commonwealth Edison Co. Dresden Nuclear Power Station in Illinois, which has been operating for 4 years, and the 5½-year-old Vallecitos Boiling Water Reactor whose construction was financed jointly by the General Electric Co. and the Pacific Gas and Electric Co., have a total installed capacity of approximately 470,000 electrical kilowatts, sufficient kilowatt-hours to supply the needs of a city of the size of Dallas, or Pittsburgh, or San Diego.

Of the other three privately financed projects, the Vallecitos Experimental Superheater Reactor (VESR), whose construction is being financed by the General Electric Co. and Empire States Atomic Development Associates, Inc., is approximately 90 percent complete, and is scheduled to reach criticality in 1963. The VESR, designed as a developmental and test facility to be used primarily to irradiate developmental superheat fuel elements, is being built adjacent to the existing Vallecitos Boiling Water Reactor (VBWR) and ultimately is intended to superheat steam produced in the VBWR. It will generate no electricity.

The Pacific Gas and Electric Co. (PG&E) Humboldt Bay reactor near Eureka, Calif., had been expected to reach criticality late in 1962. However, during preoperational checkout in late December, minor revisions to plant systems were found to be necessary. Criticality of this 48,500 electrical kilowatt boiling water reactor facility is now expected in early 1963.

The proposed Pacific Gas and Electric Co. (PG&E) Bodega Bay Plant, north of San Francisco, which will be capable of producing 313,000 electrical kilowatts was originally scheduled for completion in 1965. However, during the course of public hearings, which the California Public Utilities Commission called in March to consider PG & E's application for a certificate to begin plant construction, strong local opposition was voiced to the use of the proposed site and the PUC decision on the application was not handed down until November 9. It was an affirmative decision.

At year's end, the preliminary design of the plant had been completed, detailed design work had been initiated, and an application had been submitted to the AEC for a construction permit.

Indian Point

Consolidated Edison's Indian Point nuclear power station, located on the Hudson River about 24 miles north of New York City, attained initial criticality on August 7, 1962.

The Indian Point plant is the first commercially operated atomic power plant in the world which uses highly-enriched uranium oxide homogeneously mixed with thorium oxide as fuel. The basic reactor fuel is highly-enriched uranium 235 (U–235). The thorium is not fissionable, but when it is irradiated in the reactor core by the neutrons released during the fissioning of the U–235, it is transmuted into uranium 233, which is a fissionable material, and thus it becomes part of the total nuclear fuel charge in the reactor.

The Indian Point pressurized water reactor—built by Babcock and Wilcox Co.—is designed to furnish energy equivalent to approximately 163,000 kilowatts of electricity, but by routing the reactor steam through a separate oil-fired superheater in the conventional portion of the plant, an additional energy equivalent of 112,000 kilowatts is produced, making the total gross plant output 275,000 kwe.

By the end of October, reactor power had been gradually increased to about 50 percent of its full power level, using only one of the two superheaters. In mid-November, piping arrangements in the conventional portion of the plant were found to be preventing the reactor from attaining more than 50 percent of its full rated capacity, so the plant was shut down to make corrections. Expectations are that the plant will be back in operation by early 1963.

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Saxton

The Saxton pressurized water reactor facility, which is located at the Saxton station of the Pennsylvania Electric Co., about 22 air miles southeast of Altoona, Pa., is owned and operated by the Saxton Nuclear Experimental Corp. Although this plant, which went critical on April 12, 1962, is capable of producing approximately 3,250 net kilowatts of electricity, it was not built primarily to generate electricity. It was built principally to conduct a research and development program involving the operation of a small developmental nuclear reactor under utility company operating conditions.

The research and development program is aimed at "generating knowledge" about getting more heat, and hence more electricity, out of nuclear fuel and thereby reducing the future costs of power generation. By pushing Saxton's operating conditions beyond those now in practice in the atomic power industry, it is hoped that information will be developed which will permit better and more powerful reactors to be built in the future.

Under present design practice, nuclear engineers calculate that one linear foot of fuel rod, containing uranium oxide pellets, gives off 13 to 14 kilowatts of heat energy. During the initial phase of the AEC-sponsored 4½-year research and development program, the feasibility of raising the specific power of fuel rods up to 16 to 18 kilowatts per foot will be investigated. Phase I operation also involves the demonstration of operation of the reactor with chemical shim (boric acid solution) control at power levels up to 23.5 thermal megawatts.

Late in the year, the Commission licensed Saxton to initiate the first phase of the research and development program.

Dresden

The Dresden Nuclear Power Station is located about 50 miles southwest of Chicago near the junction of the Kankakee and DesPlaines Rivers. The world's first large-scale power reactor of the boiling water type is owned and operated by the Commonwealth Edison Co. of Chicago in association with the Nuclear Power Group, a group of companies connected with the electrical industry. The Dresden plant first produced power in April 1960, and on February 13, 1962, generated its one-billionth gross kilowatt-hour of electric energy for the Commonwealth Edison system. By the end of October, the Dresden plant's net output was 2,054,841,800 kilowatt-hours of electricity.

On November 7, Dresden was shut down for a planned outage that may extend for 3 months. During this shutdown, the reactor will undergo AEC-required inspection; general plant improvement work, which will include the complete disassembly and inspection of the

turbine; fuel reloading which will involve replacement of 192 of the 464 fuel assemblies in the core; and physics tests which will provide information for the next cores and future operations of boiling water reactors.

The Dresden Station utilizes a General Electric dual-cycle boiling water reactor which uses slightly enriched uranium dioxide as the nuclear fuel and is moderated and cooled by ordinary water. A reactor of this type has both a primary and a secondary steam system. Wet steam produced in the reactor core rises to a "primary" separating drum (where water is separated from the steam) and then flows to the turbine. Water from the drum is returned to the reactor through four "secondary" steam generators which remove additional energy from the recirculating water to form additional steam, which also flows to the turbine.

The construction and operation of the Dresden Station has contributed important technical data to the development of industrial atomic power on fuel behavior; the physics and stability of large boiling water reactor cores; actual construction, operation and maintenance, and fuel cycle costs; and the transport of radioactive material from the reactor to other parts of the system and the magnitude of radioactivity buildup in the system.

Late in 1962, Commonwealth Edison requested and the Commission approved, an 11 percent increase in the operating power level of the Dresden reactor. Commonwealth Edison anticipates that this increase will result in the generation of 200,000 rather than 180,000 kilowatts of electricity.

Vallecitos Boiling Water Reactor (VBWR)

The General Electric Co. and the Pacific Gas & Electric Co. financed the construction of the Vallecitos Boiling Water Reactor located near Pleasanton, Calif.

This 5,000 electrical kilowatt developmental nuclear power reactor project was originally undertaken primarily to obtain operating data for application to the design of the full-scale Dresden nuclear power Station which GE was building for the Commonwealth Edison Co. Once the VBWR had completed this experimental program, however, it was extensively modified and is now being used in advanced test programs, primarily those dealing with superheat fuel elements.

In September, a steam leak caused by a small crack in the stainless steel recirculation piping forced shutdown of the VBWR. The pipe section containing the crack was subjected to stress analysis and metallurgical examination to determine the reason for its failure. The defect was caused by high thermal and mechanical stresses being imposed upon the piping by the introduction of cold feedwater in the

area of the failure and by mechanical restraint near the faulty area. New recirculating piping was installed and other corrective action taken, and the VBWR is expected to resume operations in January 1963.

On October 24, the VBWR had been in operation for 5 years. During these 5 years, it has contributed design information for larger power plants, has served as a nuclear fuel proving ground, has been used as a training facility for reactor operators, has supplied 40,172,000 kilowatt-hours of electricity, and has produced 292,000,000 thermal kilowatt-hours of power.

Advanced Reactor Projects

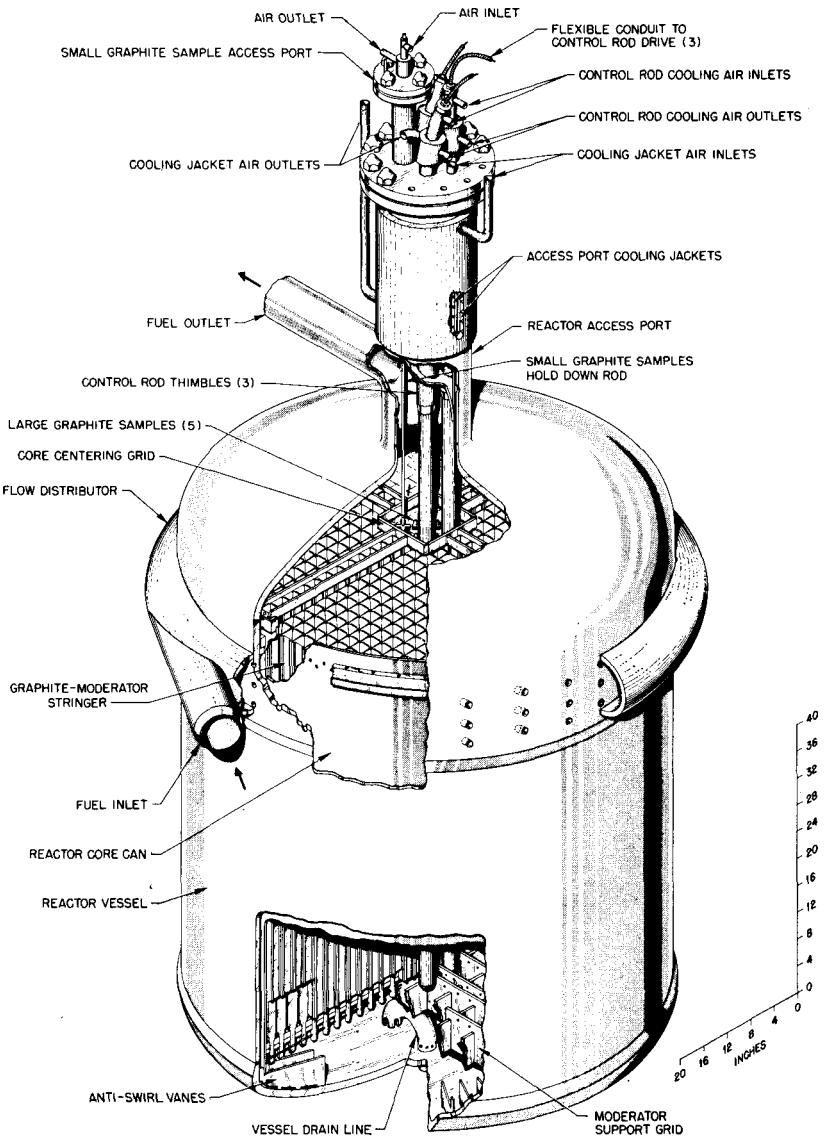
In addition to the reactor projects which are being conducted under the AEC's civilian power reactors program, the Commission is concurrently investigating several advanced reactor concepts which offer promise of advancing reactor technology. The ultimate use of these advanced concepts is not yet known . . . they may have application in the civilian power reactors program, they may have application in the space programs, the military programs, the maritime program, or in a combination of programs. It is, in fact, in order to determine their ultimate application that the AEC is building reactor experiments in which these concepts can be tested for feasibility.

Molten Salt Reactor Experiment (MSRE)

The MSRE is a 10,000 thermal kilowatt reactor experiment which is being installed in the Aircraft Reactor Test (ART) facility at the Oak Ridge National Laboratory, a building previously used in the former Aircraft Nuclear Propulsion Program. No electrical power will be produced.

The objective of the reactor experiment is to develop the technology of molten salt reactor systems to the extent required for realistic evaluation of their potential for producing economical power in large central-station plants. The molten salt reactor concept uses a mixture of molten fluoride salts as fuel and coolant, and offers the potential economic advantages of improved steam conditions and high efficiency through operation at very high temperatures and specific power. Since the fuel is in solution, no fabrication of fuel elements is necessary.

Fabrication of all reactor experiment components is expected to be completed by mid-1963 and the reactor system will be installed in the ART facility. During fiscal year 1964, the reactor system will be checked out and a series of zero power experiments will be performed.



Molten Salt Reactor. Drawing *above* shows the main components of the 10,000 thermal kilowatt Molten Salt Reactor Experiment (MSRE) now being built at Oak Ridge National Laboratory. The experiment will use a mixture of molten fluoride salts (lithium, beryllium, zirconium, thorium, uranium) as a fuel and coolant which will flow upward through the graphite moderator stringers. The reactor is expected to be in operation in 1964.

Completion of construction of the MSRE had been scheduled for mid-1963 with criticality achievement in early 1964. However, pits, crevices, and hairline cracks discovered during October in the graphite fabricated for the MSRE is expected to result in a 4-month delay in completion of the reactor.

Ultra High Temperature Reactor Experiment (UHTREX)

The Ultra High Temperature Reactor Experiment at the Los Alamos Scientific Laboratory (LASL), N. Mex., is a joint LASL-Sandia Corp. project to demonstrate the operation of gas-cooled reactors at ultra high temperatures between 2,200° F. and 2,400° F. The experiment is aimed at developing basic data which will contribute to the future development of reactors with unclad fuel which might be designed for high temperature process heat or for magnetohydrodynamic applications. No electricity will be generated in this experiment.

The experimental facility will be a 3,000 thermal kilowatt helium-cooled reactor in which the fuel elements and the high temperature heat exchanger will be constructed principally of carbon or graphite. The fuel elements will consist of short, unclad tubes of graphite impregnated with highly enriched uranium oxide. The reactor core will revolve like a gun turret and will allow continuous refueling of the reactor at full power. Reprocessing of spent fuel will be principally by burning.

A contract for the construction of the UHTREX facility was let in June, and is proceeding, but with some delay in the procurement of the steel liner for secondary containment. Construction is scheduled to be essentially complete by mid-1964, with first criticality of the facility scheduled for late 1964.

Experimental Beryllium Oxide Reactor (EBOR)

This reactor experiment is under construction at the former ANP Shield Test Pool Facility at the northern end of the AEC's National Reactor Testing Station in Idaho. The experiment, which was designed and is to be operated by the General Atomic Division of the General Dynamics Corp., is for the purpose of developing the technology of high temperature, helium-cooled, beryllium oxide-moderated reactors which can be used with a closed-cycle gas turbine or a steam cycle for small land-based power plants. Originally this concept was also thought to have potential for marine propulsion. This year, however, the Commission's Maritime Program dropped this concept as being unsuitable to its needs.

EBOR's present maximum proposed power level is to be 10,000 thermal kilowatts. Because of the experimental nature of the reactor, no provision has been made for the generation of electric power. The heat produced will be dissipated to the atmosphere through a helium-to-air heat exchanger.

The EBOR facility will be used to test fuel elements, moderator control rod drives, reactor internal structure, and instrumentation under normal, transient, and emergency conditions. Data from the operation of the facility will help bridge the gap between already-conducted in-pile loop experiments and a prototype of large plants using the high temperature, gas-cooled reactor concept.

Construction of the EBOR facility is scheduled for completion late in 1963, with first core loading to begin early in 1964. In the meantime, EBOR test fuel elements are undergoing long-term irradiation tests in the Hanford loop, and sample EBOR fuel pellets are being subjected to oxidation and thermal shock tests.

Los Alamos Molten Plutonium Reactor Experiment (LAMPRE)

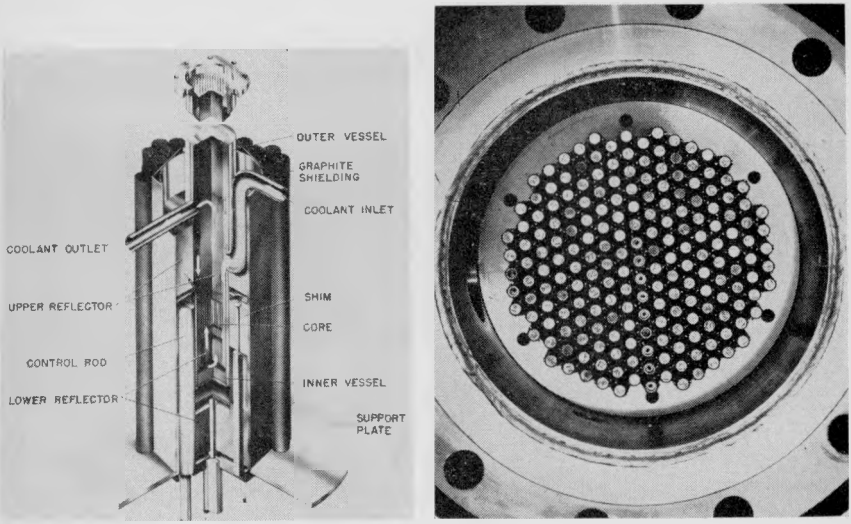
The small experimental Molten Plutonium Reactor Experiment at the Los Alamos Scientific Laboratory which first went critical with molten fuel in April 1961, is continuing to provide data for evaluating the principle of using metallic plutonium in the liquid state rather than in the solid state as a reactor fuel.

Twice during 1962, LAMPRE was shut down. First, control problems associated with the reflector shim block required modifying all the control rods to give them a scram capability. During shutdown to make these modifications, all the fuel in the core was replaced with a higher purity fuel in order to minimize the reactivity loss associated with the slag experienced in previous fuels. Upon completing these modifications, the LAMPRE again began operations, and during July it achieved its design power level output of 1,000 thermal kilowatts. No electricity is generated in the experiment.

In September, LAMPRE again experienced a reactivity loss as a result of a leaky fuel capsule. By the end of the year, repairs had been completed, and LAMPRE was again in operation.

Proposed Work

Other reactor concepts which offer interesting potential and on which success in research and development work may lead to reactor experiments are the settled bed reactor—a concept which features fixed fuel during power operation and mobile or fluidized fuel during fuel handling periods; and an advanced high temperature gas reactor—a high temperature, light weight, high power-density reactor.



LAMPRE–1. Diagram on *left* shows the major components of the first Los Alamos Molten Plutonium Reactor Experiment (LAMPRE–1) and photo, *right*, shows the open top of the reactor. The tops of the fuel handling rods show, through the letter-number designation, the relative position of fuel containers in the core. Loading of a second core in the reactor was completed in April 1962. Examination of the first core which had been in a molten state, at temperatures of 450–500° C. for approximately ten months, showed no leakage of the plutonium from the containers.

Other advanced systems work is directed toward searching out means by which electricity can be produced directly from the heat of fission. Thermionic converters, regenerative fuel cells, barium vapor thermionic cells, and liquid metal magneto-hydrodynamic generators, and also a device to extract electrical energy directly from charged fission particles, are being investigated under this program.

MARITIME REACTORS PROGRAM

The maritime reactors program objective is the development of demonstrably safe and reliable and commercially competitive nuclear-powered merchant ships. The program is jointly administered by the AEC—which is concerned with the nuclear phases of the program—and the Maritime Administration—which is concerned with associated non-nuclear developments.

NS Savannah

The first application of nuclear power to merchant ship propulsion became a reality on May 1 when the Maritime Administration accepted the 22,000-ton Nuclear Ship *Savannah* from her builder, the New York

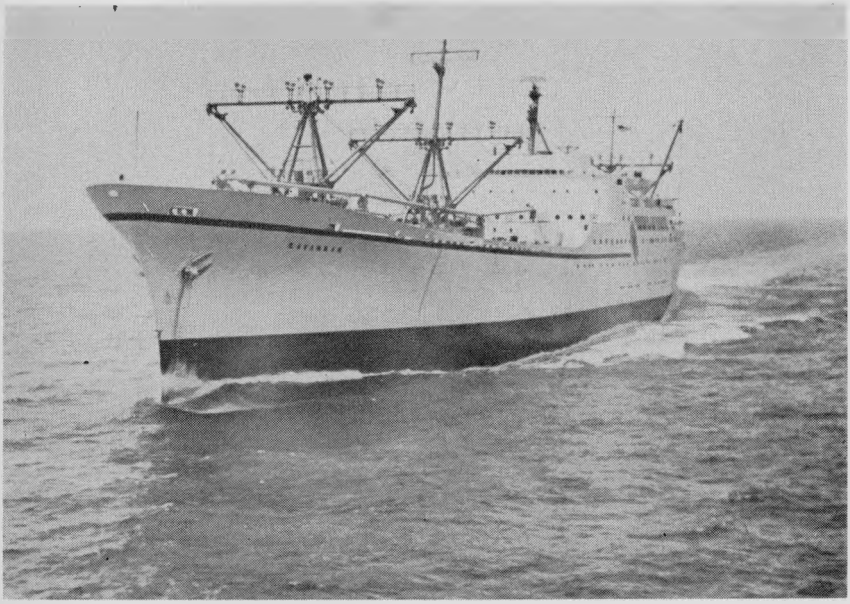
Shipbuilding Co. At the same time, operating responsibility was assumed by States Marine Lines as general agents of the Maritime Administration. Acceptance of the *Savannah*—which uses a 69,000 thermal kilowatt pressurized water reactor built by the Babcock & Wilcox Co.—followed successful completion of a series of sea trials during which her power plant exceeded its design specifications by delivering 22,314 horsepower to the shaft as the ship achieved a maximum speed of 24 knots. The power plant was designed to normally develop 20,000 shaft horsepower and drive the ship at a cruising speed of 20 knots. During her initial sea trials, the *Savannah* also demonstrated that nuclear-powered merchant ships can operate on long runs at high sustained speeds.



Savannah at Savannah. The NS *Savannah's* first visit to a commercial port was at her namesake city, Savannah, Ga., on August 22, 1962. A civic holiday welcomed the gleaming white ship, shown in the photo as she moved up the Savannah River escorted by a water-spewing fireboat and numerous small craft. While at Savannah, cargo was loaded for subsequent delivery at Pacific Coast ports during her trip to the Seattle World's Fair in October.

Port Visits

For the next year or two the *Savannah* will make visits to various major domestic ports and to those major foreign ports which have agreed to her entry. The ship's first regular port of call was to her official home port of Savannah, Ga., on August 22, and on September 13 she sailed from Norfolk, Va., for Seattle, Wash. On this voyage, some 30 passengers and several hundred tons of cargo, loaded at Savannah and Norfolk, were carried. Enroute from Seattle to Galveston, Tex., the *Savannah* made visits to San Francisco, Los Angeles, Honolulu, Portland, San Diego, and Balboa, C.Z. Through November, more than 175,000 visitors had toured the *Savannah*. During 1963, she will visit ports on the Gulf and Atlantic Coasts and make her maiden foreign voyage to Europe. Although the primary purpose of these demonstration voyages is to show the world that nuclear-powered ships are dependable and safe and that nuclear power can be used as an instrument of peace for the benefit of mankind, they will also show the world one of the most beautiful cargo-passenger ships afloat.



Savannah at Sea. The NS *Savannah*, the world's first nuclear-powered merchant ship, was given her sea trials during the early part of 1962, and on May 1, the Maritime Administration accepted her from the builder, New York Shipbuilding Corp. During the trials, the *Savannah's* pressurized water reactor power plant surpassed design specifications by delivering 22,314 shaft horsepower, propelling the ship at 24 knots an hour, as against the anticipated 20,000 shaft horsepower and 20 knots. The nuclear portion of the ship's propulsion system was built by Babcock & Wilcox Co. under AEC contract.

The world's first nuclear-powered cargo-passenger ship is a stackless, gleaming-white, 595-foot, 6-decked vessel which will carry a crew of about 110, approximately 10,000 tons of dry cargo, and 60 passengers.

Safe Ship

Every safety precaution has been taken to insure that no damage can be done, or be caused by radiation from, to her reactor. To protect her reactor from causing a radiation hazard, it is enclosed in a high strength carbon steel primary shield covered with a layer of lead two to four inches thick. This shield will permit a wall of water 33 inches thick to surround the reactor and, when filled, constitutes the first line of resistance to radiation from within the reactor. Surrounding this shield is a heavy steel containment shell, the top half of which is covered by a 6-inch layer of lead plus a 6-inch layer of polyethylene and the bottom half of which is surrounded by a 4-foot thick wall of reinforced concrete. This also protects the crew and passengers from radiation.

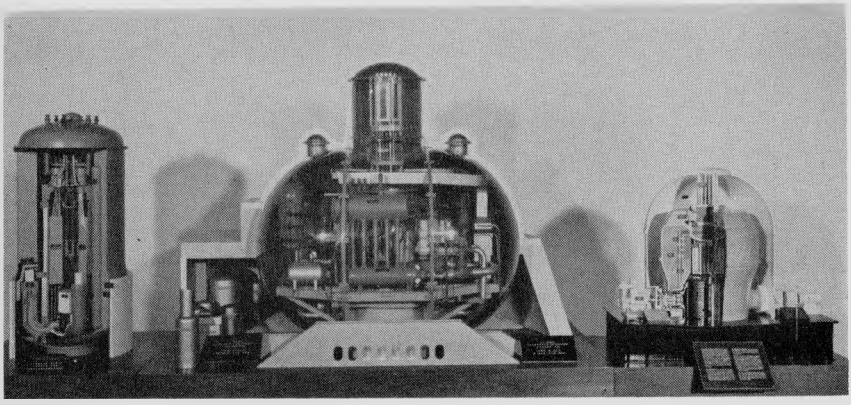
The reactor is located amidship in a compartment which is so designed and constructed that, in the event of a broadside collision opposite the reactor space, the ramming ship would have to penetrate a total of 17 feet of stiffened ship structure, two heavy steel collision bulkheads (partitions), and 2 feet of collision mat made up of alternate layers of inch-thick steel and 3-inch redwood, before reaching the heavy reactor containment shell. In short, the *Savannah's* design and construction is such that should she collide with any of the ships making up over 98 percent of the world's merchant fleet, her nuclear reactor would suffer no damage.

ASSOCIATED WORK

The NS *Savannah* is a first-of-a-kind prototype and hence was not intended to be commercially competitive with conventional merchant ships. The maritime reactors program is continuing, therefore, to support research and development on reactor systems that offer promise of reducing operating costs and thus meeting the competitive requirements of merchant ship operators.

New Reactor Designs

Extensive studies have been made which indicate two reactor designs offer promise of developing into nuclear merchant ship propulsion plants capable of achieving significantly improved transoceanic transportation service. The two reactor concepts, developed as the result of experience with the NS *Savannah* and during the now defunct



Proposed Propulsion Reactors. Operating experience with the NS *Savannah's* pressurized water reactor propulsion system as well as technology developed under the old Aircraft Nuclear Propulsion (ANP) program has led to conceptual design of two potential nuclear propulsion systems. Photo shows scale models of the Babcock & Wilcox Co. CNSG (Consolidated Nuclear Steam Generator) on *left;* the NS *Savannah's* reactor in the *center;* and the air-cooled, high enrichment water-moderated nuclear steam generator (630–A) proposed by General Electric Co. on the *right.* Both concepts appear promising and are compact, lightweight types with the steam boilers located in the reactor vessel which would be submerged in a pool of contained water. Neither reactor requires the bulky secondary shielding that surrounds the *Savannah's* present reactor. The 630–A uses technology developed under the ANP program which was terminated during 1961.

Aircraft Nuclear Propulsion (ANP) project, are of the compact consolidated type with the boilers in the reactor vessel, the primary coolant confined totally within primary shielding, and the reactor vessel effectively submerged in a pool of contained water. In neither reactor is a heavy and bulky secondary shield required.

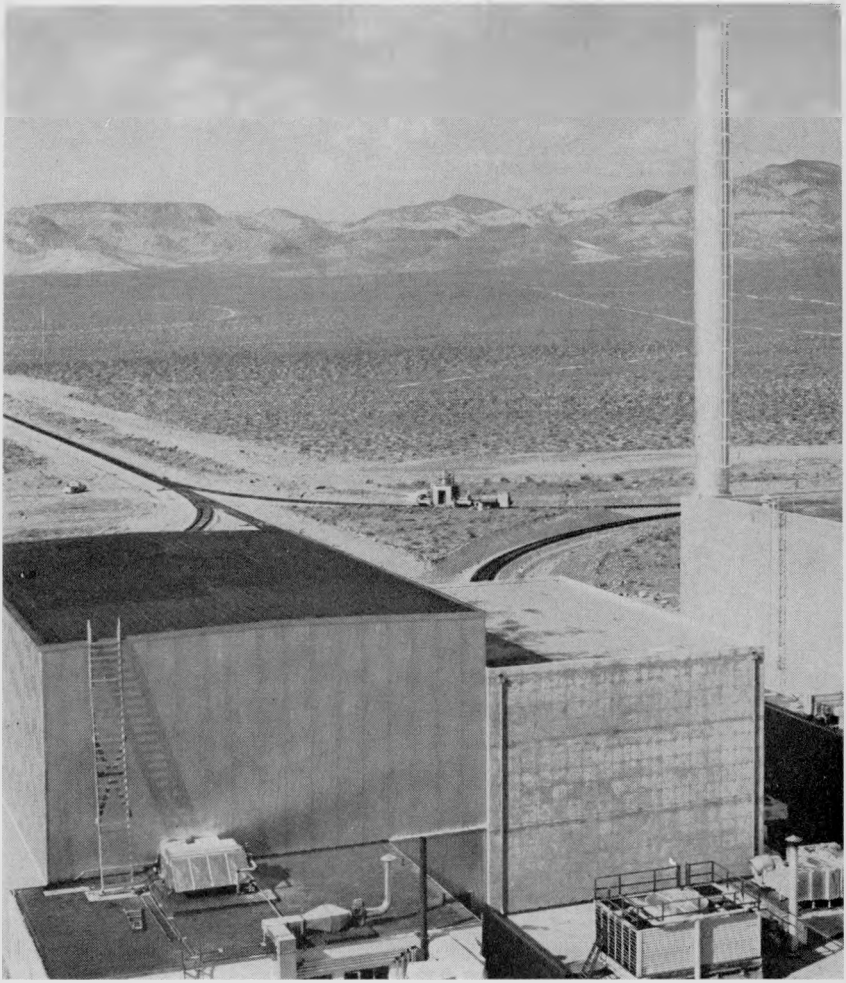
One of these concepts is a PWR–type consolidated nuclear steam generator under study by the Babcock & Wilcox Co. The other is an air-cooled, high enrichment water moderated nuclear steam generator being studied by the General Electric Co. which uses reactor technology developed under the aircraft nuclear propulsion (ANP) program.

SPACE PROPULSION PROGRAM

The space propulsion program has as its objective the development of reactors and related nuclear technology for the propulsion of space vehicles.

A few years ago talk about vehicles being propelled into space, of humans landing on the moon, of two spacecraft being coupled together while they were orbiting the earth—was considered as in the

realm of science fiction. Today, however, the United States and other major nations are expending great effort toward bringing about these very events. Just as Jules Verne's fairytale submarine came true in the nuclear-powered *Nautilus*, so, too, has the "fairytale" of traveling weightless in space come true for United States and Russian astronauts.



Rocket Station. Photo shows a portion of the Nuclear Rocket Development Station, located about 25 miles northwest of Mercury on the Commission's Nevada Test Site reservation. In the foreground is a portion of the MAD Building (Maintenance, Assembly, and Disassembly). One of the KIWI experimental reactors—designed and constructed by Los Alamos Scientific Laboratory—is visible on a remotely controlled railroad car in the middle distance. The flightless KIWI reactors are being used to develop nuclear rocket technology under the ROVER program.

PROJECT ROVER

High specific impulse—thrust produced per pound per second of propellent flow—plus performance is the key to extensive outer space exploration. Since many space missions of interest cannot be accomplished using chemical rocket engines, the development of nuclear rockets is essential. Hence, the ROVER program—code name for the coordinated AEC–NASA program for the development of qualified nuclear rocket engines for the accomplishment of operational space missions—came into being.

The division of responsibility between the two agencies is that the AEC is responsible for the development of reactors and reactor technology; NASA is responsible for the development of nuclear engines and related engine technology, and for the integration of the reactors into engines. The program is administered by a single joint AEC–NASA office, the Space Nuclear Propulsion Office (SNPO) located in the Commission's Germantown, Md., headquarters, which has operating extensions in Albuquerque, Cleveland, and Las Vegas.

Four-Part Program

The nuclear rocket program may be broken down into four functional components—the KIWI, NERVA, and RIFT projects, and Advanced Technology. The KIWI, NERVA and Advanced Technology efforts are part of the joint program, whereas RIFT is a NASA program which is coordinated with the other three.

The KIWI project, under development at the AEC's Los Alamos Scientific Laboratory (LASL), is the "backbone" of the program, for from the KIWI project will come the basic design of the reactor that will be engineered into the NERVA engine, which is to be flight-tested in the RIFT stage vehicle. The Advanced Technology project is developing the technology which will be needed for the advanced reactors and rocket engines of the future.

KIWI Reactors

One of the first steps taken by the Los Alamos Scientific Laboratory (LASL) toward the development of nuclear rocket reactors was the development and fabrication of facilities in which various fuels, materials, and components could be assembled, tested, disassembled, and examined to determine their ability to withstand extreme temperatures and attain high power densities. Following successful proof-tests of these key items, a series of ground-based experimental reactors, dubbed "KIWI" after a New Zealand flightless bird, was designed, fabricated and ground tested.

KIWI–A *series.* The first KIWI–A reactor was successfully operated in July 1959 using high pressure hydrogen gas as propellant and water as the propellant-shell and nozzle coolant. Two modified and improved KIWI–A reactors achieved more advanced test performance goals in 1960. These KIWI reactor experiments demonstrated the feasibility of developing nuclear reactors for rocket propulsion. The next step in the development of nuclear propulsion, the KIWI–B reactors, has been to demonstrate the operation of reactors at power levels and temperatures useful in space missions, using liquid hydrogen coolant.

KIWI–B *reactors.* The completion of facilities and the successful operation of a liquid hydrogen pump and regeneratively cooled nozzle were among the major Project ROVER technical achievements of 1962. The first power operation of a reactor on liquid hydrogen feed was attained during the KIWI–B1B reactor test of September 1. This test demonstrated that the rapid startup of the reactor with liquid hydrogen presents no insoluble problems. Prior to the September 1 tests, a series of experimental runs were made with liquid hydrogen on a U–238-fueled reactor which could not go critical. These "cold flow" tests, completed in July, yielded much information regarding liquid hydrogen operation.

In November, the first of the KIWI–B4 reactors—the KIWI–B4A—was tested. This reactor is externally similar to the KIWI–B1 but has a substantially different core design. Almost as soon as the test was started, flashes of light indicated that material from the core was being carried away in the exhaust jet. Core disassembly revealed that thermal insulation components and fuel elements were broken or cracked, presumably from vibrations generated within the reactor. The reactor design is being modified to reduce the possibility of mechanical vibrations. Components, subassembly, and full-scale mechanical testing and cold-flow testing will be conducted to check suitability of redesigns and to overcome mechanical difficulties prior to further hot runs.

NERVA Work

While work is progressing at LASL on the development of prototype flyable reactor technology, the Aerojet-General Corp.-Westinghouse Electric Corp. industrial team under a 5-year contract signed in January with SNPO, is developing a Nuclear Engine for Rocket Vehicle Application (NERVA) based on the KIWI technology. The primary difference between the KIWI and the NERVA is that the KIWI is a developmental reactor system; the NERVA will be engi-

neered for ultimate flight. In the NERVA project, the basic KIWI reactor is adapted to withstand the loads placed upon the reactor in ground handling and flight and then developed into a complete nuclear rocket engine, NERVA.

RIFT Vehicle

Following successful completion of ground tests, which are scheduled to start in late 1964, the NERVA engine will be flight-tested in a RIFT (Reactor-in-Flight-Test) stage on which Lockheed Missiles and Space Co. has already begun work. The RIFT stage will be designed so that it can be developed to an operational upper stage on an advanced Saturn chemical booster. Such a vehicle would be potentially capable of landing large payloads on the moon for lunar-base supply and other missions. The first flight test of the RIFT stage will be as a third stage on a Saturn C–S launch vehicle. The flight will be on a ballistic trajectory to a predetermined deep ocean impact point. The RIFT flight tests are presently scheduled for the 1967–68 period.

Advanced Technology Work

Even though the development of first generation nuclear rocket engines is still in the early stages, serious consideration is already being given to future engines in an advanced technology program. Work began during 1962 on the design and development of advanced reactors, pumps, nozzles, and other components for ground test reactors. The major effort—reactor development—continues to be centered at LASL, with a small reactor effort at Argonne National Laboratory evaluating the potential use in the nuclear rocket program of solid core reactors of other materials. Advanced research and technology on engine systems components, such as advanced flow systems and nozzles, is centered at NASA's Lewis Research Center, with supporting effort by various industrial contractors.

Development Station Established

In February, the Jackass Flats area of the Commission's Nevada Test Site was designated as the Nuclear Rocket Development Station (NRDS). Additions and modifications to the NRDS facilities to permit the conduct of more complex, higher-power tests are progressing. The Nevada Extension of the SNPO at Las Vegas, which became fully operational in October, was established to manage the

NRDS, where all phases of ROVER test operations are conducted. Catalytic Construction Co. was retained to furnish construction management services at the NRDS.

Other Contracts

Three other important steps taken during 1962 in the development of the nuclear rocket were the execution on June 28 of a contract between NASA and Lockheed Missiles and Space Co. for the development and initial flight test of the RIFT stage, the first nuclear vehicle; the extension of the contract with Aerojet-General to cover the entire engine development effort through September 30, 1966; and the selection of five companies—Aerojet-General Nucleonics, General Atomic, Metals & Controls Nuclear (Texas Instruments), National Carbon Co., and United Nuclear Corp.—to participate as candidate suppliers in a cooperative program aimed at providing industrial capability to produce nuclear rocket fuel elements.



Berkeley Tour. President Kennedy toured the AEC's Lawrence Radiation Laboratory, located on the University of California's Berkeley campus, on March 23. Photo, taken at the entrance to the Laboratory's Chemistry Building shows, *left to right*, Dr. Norris Bradbury, Director of the Los Alamos (N. Mex.) Scientific Laboratory which is contractor operated for the Commission by the University of California; Dr. John S. Foster, Director of Lawrence Radiation Laboratory's Livermore facility; Dr. Edwin M. McMillan, Director of Lawrence Radiation Laboratory; AEC Chairman Glenn T. Seaborg; President Kennedy; Dr. Edward Teller, Associate Director of Lawrence Radiation Laboratory; Secretary of Defense Robert S. McNamara; Dr. Harold Brown, Director of Defense Research and Engineering, U.S. Department of Defense.

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ROVER Briefing. President John F. Kennedy showed deep concentration on the subject as he was briefed on various developmental aspects of Project ROVER at the AEC's Los Alamos Scientific Laboratory (LASL). The briefing was held at the New Mexico facility on December 7 prior to the President's December 8 tour of the ROVER test facilities at the Nevada Test Site. Photo, taken during the briefing, shows *left to right:* AEC Chairman Glenn T. Seaborg; President Kennedy; Dr. Norris E. Bradbury, Director of LASL; and New Mexico Senator Clinton P. Anderson, former Chairman of the Joint Committee on Atomic Energy.

Presidential Visit

President Kennedy visited several AEC facilities on December 7 and 8, 1962, primarily for the purpose of receiving on-site briefings on the AEC–NASA Rover program for the development of nuclear space propulsion, and of inspecting experimental facilities in the ROVER program. On December 7, he visited the Los Alamos Scientific Laboratory at Los Alamos, N. Mex., and the Sandia Laboratory in Albuquerque, N. Mex. The following day, he visited the Nuclear Rocket Development Station in Nevada.

At Los Alamos, the President discussed the ROVER program with Laboratory officials and viewed a cut-away KIWI reactor. At the Nuclear Rocket Development Station, he inspected the Reactor Maintenance, Assembly and Disassembly (R–MAD) Building, Test Cell C, and Engine Test Stand No. 1. In the R–MAD Building, he watched a portion of the disassembly of the KIWI B–4A reactor, which had been tested on November 30.



Presidential Visit. Scientists, technicians, and administrators in the nation's nuclear rocket development program were on hand as President Kennedy toured the Nuclear Rocket Development Station at the AEC's Nevada Test Site on December 8. Photo shows the President leaving the "MAD" (Maintenance-Assembly-Disassembly) Building where reactors used under Project ROVER are asembled for operational tests and disassembled for study after the tests. Shown, *left to right*, are: Dr. Keith Boyer, director of nuclear rocket reactor testing for the Los Alamos Scientific Laboratory (LASL); AEC Chairman Glenn T. Seaborg; President Kennedy; Dr. Alvin C. Graves, director of all LASL test programs; Harold B. Finger, Manager, AEC–NASA Space Nuclear Propulsion Office; and Duncan Curry, Elmer J. Sowder, Lawrence Rice, Charles Fernstermacher, James Henshall, and H. T. Knight, all members of the LASL nuclear rocket reactor test staff.

The President also was given an on-site briefing on the work of Sandia Laboratory, where non-nuclear components of nuclear weapons are designed, developed, and tested. En route to the Nuclear Rocket Development Station, he flew over areas of the adjacent Nevada Test Site where underground nuclear tests have been conducted, and also had an aerial view of the large crater produced by the Sedan experiment on July 6, 1962. This experiment, part of the Plowshare program to investigate peaceful uses of nuclear explosives, provided information on the potentialities of nuclear explosives for large excavation projects.

The facilities were shown to the President by AEC Chairman Glenn T. Seaborg and other Commission officials, including Commissioners Leland J. Haworth and James T. Ramey. Vice President Johnson accompanied the President on part of the trip.

Earlier in the year, during March, the President had visited the Commission's Lawrence Radiation Laboratory on the University of California's Berkeley campus.

PROJECT PLUTO

Project PLUTO, a coordinated effort of the AEC and the Department of Defense (Air Force), was originally initiated to develop technology and to design, build, and test experimental reactors that would demonstrate the feasibility of using nuclear energy for ramjet propulsion. The PLUTO program has had as its objective since 1956 the development of an advanced-type reactor which can be incorporated into a ramjet engine to propel high-speed, low-altitude, extended-range missiles.

Ramjet Principle

A ramjet engine has been described as a "flying stovepipe" since it has no moving parts. Instead of using a compressor as in a turbojet, the ramjet uses the ram pressure created by the forward movement of the missile to force air into the missile inlet and thence to the combustion chamber. In the nuclear ramjet, a nuclear reactor takes the place of the usual combustion chamber. The compressed air passes through the reactor core channels, is heated to a high temperature, and is exhausted through a nozzle, producing thrust.

The ramjet produces no thrust unless moving in flight and must travel at supersonic speeds in order to receive sufficient air to operate efficiently; hence, it must have either a rocket or turbojet engine to boost it to flight speed. Since the ramjet is an "air-breathing" engine, it can achieve thrust only within the earth's atmosphere, as contrasted with a rocket which can travel in the vacuum of space.

A high-speed missile propelled by chemically derived power consumes tremendous amounts of chemical fuel. The heavy fuel load and complex combustion system imposed by chemical fuels greatly limits the range of the missile. In the nuclear ramjet, fuel is consumed, but it is nuclear fuel and fissioning of 1 pound of uranium can produce as much heat as the burning of about 2 million pounds of jet fuel. Thus, the nuclear ramjet missile would have almost unlimited range at very low altitude and high speed, and have a payload capability that would not be possible with chemical fuels.

Tory Reactor

PLUTO reactor development is being conducted by the AEC's Lawrence Radiation Laboratory at Livermore, Calif. The first step toward the development of a ramjet reactor was the construction of a series of test reactors—designated TORY—to provide the engineering, thermodynamic, and nuclear experience basic to the development of such a reactor. The initial engineering test reactor—designated TORY IIA—was successfully tested in the fall of 1961 and demonstrated the feasibility of a reactor for nuclear ramjet propulsion. The second reactor—TORY IIC—now under construction, is designed to bridge the gap between the TORY IIA engineering test device and a flyable power plant. Its higher power, higher temperature, and larger reactor core will meet the general requirements for a flight propulsion system. Testing of the TORY IIC is to begin during the summer of 1963.

Future Work

In a letter of January 3, the Department of Defense (Air Force) requested that the AEC continue with the PLUTO program beyond the TORY IIC phase and into a propulsion system ground test. Then, early in April, the Navy requested that the Commission undertake studies of nuclear reactors for potential use in sea-based nuclear ramjet missile applications, including launch from POLARIS submarines. Subsequently, by a November 19 letter, the Department of Defense guidance on PLUTO specifically excluded the propulsion system ground test program, but did provide strong support for the completion of the TORY IIC program, for the continuation of the research and development effort to improve fuel element technology and reactor design, and for the continuation of studies of an optimum reactor applicable to sea-based missiles.

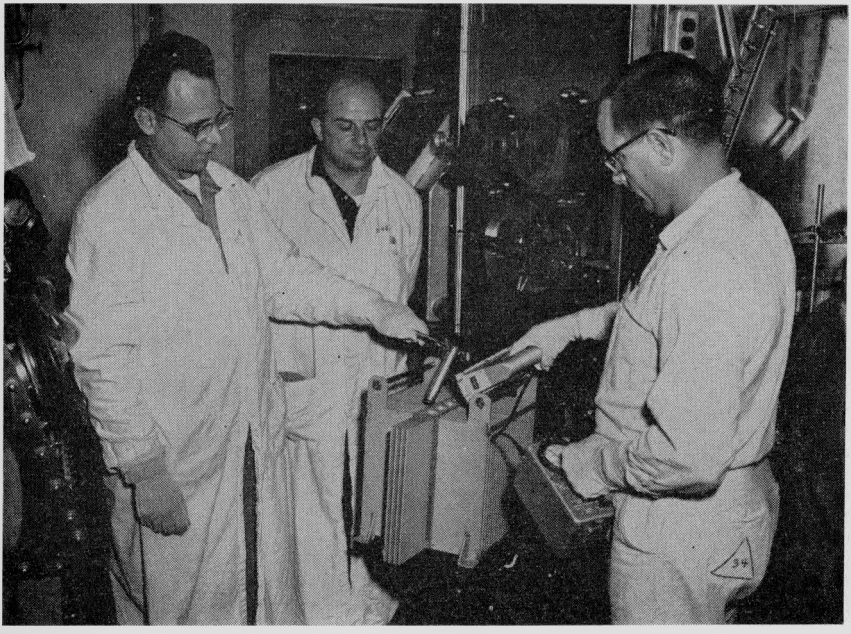
THE SNAP PROGRAM

The SNAP (Systems for Nuclear Auxiliary Power) program has as its objective the development of compact, lightweight, long-lived and dependable nuclear-electric power devices for space vehicles and other specialized applications. At least one type of the devices developed under the SNAP program is already quite well-known—the "atomic batteries" which were shot aloft during June and November 1961 to power two of the transmitters in the Navy's TRANSIT–4A and 4B experimental navigational satellites.

Nuclear energy is particularly well-suited to fulfilling the power requirements of space vehicles and unmanned devices because of its

capability for high energy output at low weights with long-term, reliable performance.

In applying nuclear energy to lightweight power units, two sources of nuclear heat were selected as affording the greatest potential for meeting both current and future power needs—radioisotope decay and nuclear fission.



SNAP–9A Source. One of the plutonium 238 heat sources to be used in a SNAP–9A power source is shown being loaded into its shipping container at the Commission's Mound Laboratory, Miamisburg, Ohio. Even before going into orbit around the earth, the plutonium will have traveled a considerable distance. The plutonium was produced at the AEC's Savannah River plant in South Carolina; shipped to the Mound Laboratory for fabrication and encapsulation as a heat source; and then transported to the Martin-Marietta Corp. facility at Baltimore, Md., for incorporation into the SNAP–9A thermoelectric generator. Subsequently, it will be aboard the Navy's TRANSIT–5A navigational aid satellite which is scheduled to be launched in early 1963. The array of baffles on the container is necessary to carry off the high degree of heat generated by the plutonium 238. The 25-watt SNAP generator can provide electric power for the TRANSIT–5A's instruments and transmitters for 250 years although the satellite itself has a design life of only five years. The SNAP–9A TRANSIT unit uses a generator developed by Martin-Marietta and a thermoelectric assembly developed by the Minnesota Mining and Manufacturing Co. The TRANSIT satellites, which provide a worldwide means for ships and aircraft to determine accurately their positions electronically rather than through celestial observations, were developed for the Navy by the Johns Hopkins University Applied Physics Laboratory. The first such satellite, TRANSIT–4A, was launched in June 1961 and is still operating. It used a 2.7-watt SNAP–3 type generator which continues to power two of the four radio transmitters in the satellite.

Isotopic Power Units

The principles underlying radioisotopic power are simple. Heat is generated when the particulate and electromagnetic radiations emitted by a radioisotope are absorbed in the surrounding containment material. The heat is then partially converted into electricity by a suitable energy-conversion device [11] with the remaining heat being dissipated to the external environment. Electrical power of up to several hundred watts can be generated by this means. And, since these radioisotope-fueled generators convert the heat produced by radioisotope decay directly into useful electricity, they have no moving parts. Thus, they are ideally suited for use in satellite and in unattended land- and sea-based installations. Isotopic SNAP units are developed for the Commission by the Martin-Marietta Corp., Baltimore, Md.; General Instruments Corp., Newark, N.J.; and Royal Research Corp., Hayward, Calif.

TABLE 1.—STATUS OF SNAP RADIOISOTOPE UNITS

November 1962

SNAP No.	Power electrical (watts)	Life (years)	Application	Fuel	Status
3	3.5	½	Demonstration (AEC)	Po-210	Completed.
3	2.7	5	TRANSIT 4A and 4B	Pu-238	Launched June 1961 and Nov. 1961.
7A	5	2	Light Buoy (CG)	Sr-90	Delivered Dec. 1961.
7B	30	2	Land Light (CG)	Sr-90	Scheduled Dec. 1962.
7C	5	2	Weather Station (Navy)	Sr-90	Installed in Antarctica.
7D	30	2	Boat Weather Station (Navy).	Sr-90	Scheduled delivery early 1963.
7E	4	2	Deepsea (Navy)	Sr-90	Scheduled delivery to ONR early 1963.
9A	20	5	TRANSIT (Navy)	Pu-238	Delivered to AEC.
11	20	½	SURVEYOR (NASA)	Cm-242	Scheduled delivery 1966.
13	12.5	½	Thermionic Demonstration Unit.	Cm-242	Electrically heated units under test.
Sentry	2.5	2	Weather Station (Weather Bureau).	Sr-90	Installed in Arctic Aug. 1961.
Cs Generator	5	2	Deepsea (Lamont Geo. Laboratory).	Cs-137	Under development.
MFP Generator	5-10	1-5	Demonstration Unit	MFP	Prototype generator under development.
Generator Study	500	1	Space	Ce-144	Design study.
IMP	40	1-5	Interplanetary Monitoring Probe.	Pu-238	Feasibility and design study.

[11] *Energy-conversion devices:*
(1) *Thermoelectric conversion*—The principle upon which thermoelectric conversion is based is the *Seebeck effect,* in which electricity is produced by the unequal heating of a circuit composed of two dissimilar metals. (2) *Thermionic conversion*—In thermionic conversion two metals of different energy are placed in close proximity with a vacuum or an ionized medium between. The high-energy material is heated and the electrons which "boil off" its surface are collected by the cooler low-energy material, creating a flow of electricity. (3) *Turboelectric conversion*—In turboelectric conversion, the heat boils a fluid which drives a turbo-generator to produce electricity.

Strontium 90-fueled Units

Four units, which use the radioisotope strontium 90 as the heat source, have been delivered to the Navy and the Coast Guard.

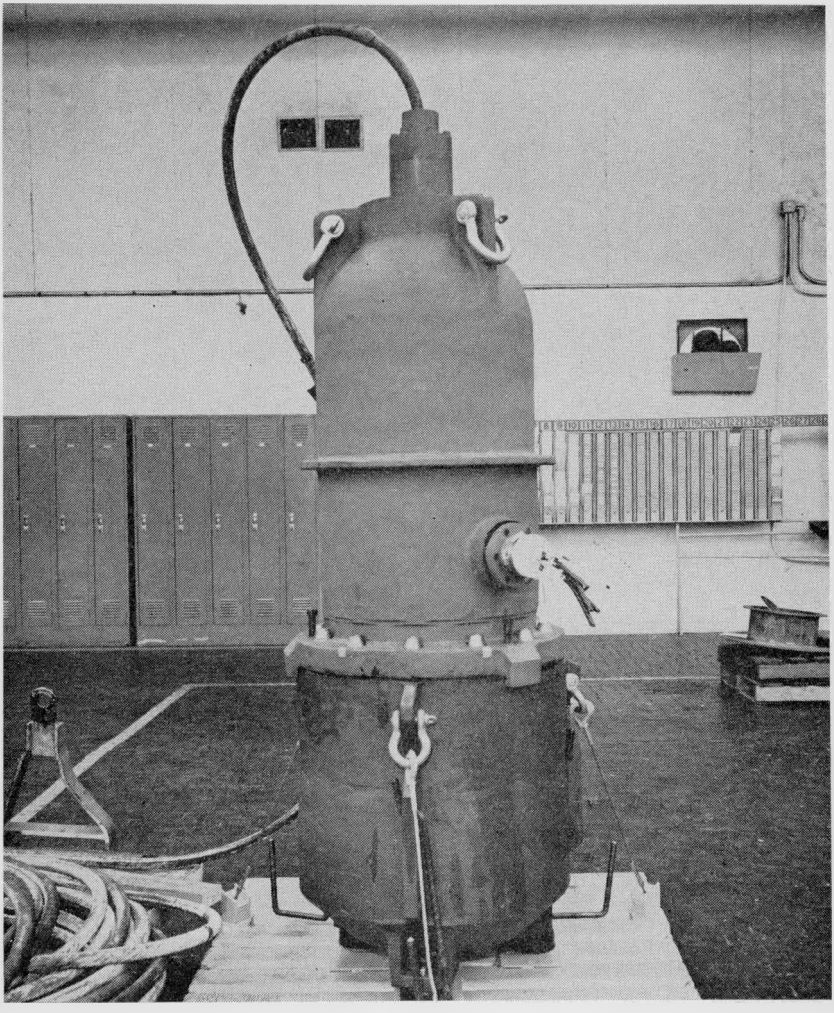
Of the two Coast Guard units, one—SNAP–7A—began supplying power to a floating navigational buoy in Baltimore's harbor during December 1961. Its operation at first was highly satisfactory, but early in 1962 the unit experienced a slow, unexpected deterioration in performance due to a buildup in gas pressure. The generator was returned to its developer in July for examination, testing, and modification, and is expected to be back in operating condition by the end of the year. The other Coast Guard unit—SNAP–7B—was placed in operation late this year to power a shore-based navigational light at the Curtis Bay Coast Guard Yard.

Of the two Navy units, SNAP–7C was flown in early February to the Antarctica to power an automatic, unmanned weather station located in the ice at Minna Bluff near McMurdo Sound. The second unit, SNAP–7E, was delivered to the Navy in September and transported by ship to a site near Bermuda where it was to serve as an underwater sound source. As it was being lowered into the sea, sonar reception began fading and then ceased. The device was recovered, returned to AEC custody, and shipped to the fabricator. Examination disclosed that salt water had leaked into the top dome and had corroded the leads and electronic components inside. Restoration of the unit is in progess, and redelivery to the Navy is expected early in 1963.

Another strontium 90-fueled unit being developed for Navy use, SNAP–7D, was completed and fueled in June and was to have been delivered to the Navy in October. However, due to a delay in delivery of their weather station equipment, the Navy does not expect to accept delivery of the unit until early next year. The device will be used by the Navy to supply power to an unmanned weather boat anchored in the Gulf of Mexico.

Plutonium 238-fueled Units

The two SNAP–3 units in the Navy TRANSIT–4 satellites, launched during 1961, use plutonium 238 as the heat source for the thermoelectric power devices. Both of these units had been operating successfully until mid-1962 when the SNAP–3 unit in the TRANSIT–4B failed. The exact cause of its failure may never be known for sure unless the satellite can be recovered from orbit—in a future recovery effort from a manned spacecraft—and analyzed. In early



SNAP–7E. A strontium 90-fueled, radioisotope thermoelectric generator designated SNAP–7E was delivered to the Commission by Martin-Marietta Corp. during September. The generator, containing 36,000 curies of Sr–90 titanate as a heat source, will be used by the U.S. Navy's Office of Naval Research to power an acoustic navigation aid located in a deep-sea environment. It has a design output of eight electrical watts. Depleted uranium is used for biological shielding purposes. Initial attempts to launch the unit near Bermuda were unsuccessful due to a leakage through the pressure dome. The deficiency is being corrected and the unit is expected to be put into operation in early 1963.

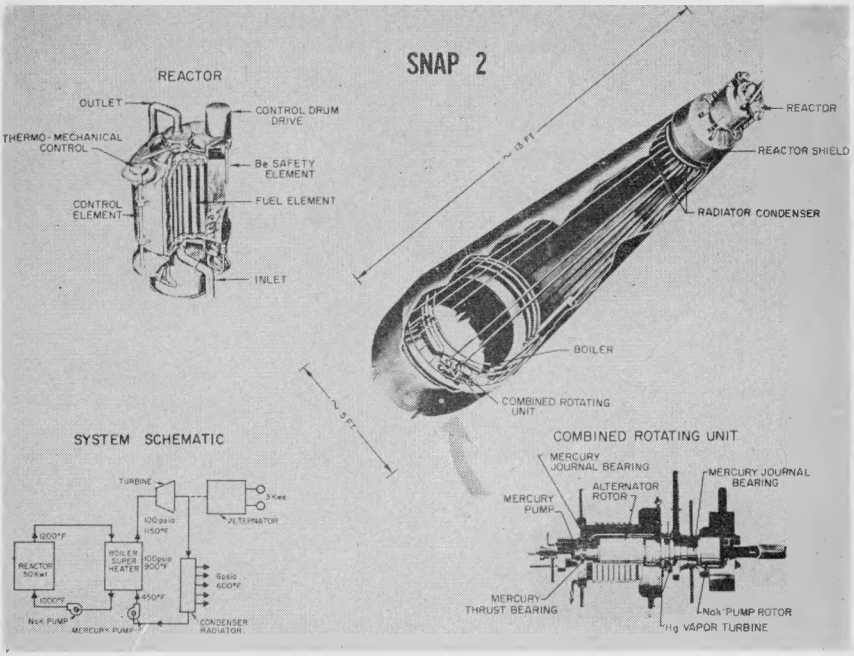
June, the generator voltage data from the 4B satellite indicated a very abrupt drop. After wavering up and down for a week or so, it dropped to a point where it would no longer power the satellite transmitters. It is believed this type of failure could be caused by a capacitor shorting-out intermittently, then staying in a shorted condition. Best estimates are that the failure is one of those to be expected with electronic components, and that the SNAP generator continues to deliver electricity as it should, but that the electricity cannot get to the load where it can perform a useful purpose. The SNAP–3 generator in TRANSIT–4A continues to operate satisfactorily, and at year's end had been in orbit 18 months and had generated 36 thousand watt-hours of electricity in space.

SNAP–9A is a plutonium 238-fueled thermoelectric unit larger and heavier than SNAP–3 and capable of generating 25 watts of electricity. During 1962, three SNAP–9A generators were fabricated, fueled, and tested, and are now awaiting delivery to the Navy for launching during 1963 in their operational prototype TRANSIT–5 series of navigational satellites. The major SNAP–9A effort in 1962 was devoted to testing the integrity of the capsule in which the fuel for the generators is encased. Generators and bare fuel capsules were subjected to rigorous impact and fire tests to ascertain the behavior of the units under flight conditions.

Other SNAP Isotopic Units

Two other units, SNAP–11 and SNAP–13, which will use the curium 242 isotope as their heat source, are under development for use in space missions. Early in 1962, the Martin-Marietta Corp. was awarded a contract for the development of the SNAP–11 generator, a 25-watt thermoelectric unit with a mission lifetime of 120 days. Prototype SNAP–11 units will be available to NASA for 1965 launchings in their unmanned soft lunar exploration program, Project SURVEYOR. The SNAP–13 thermionic generator is designed in line with the SURVEYOR system requirements so it may serve as a standby unit for SNAP–11, delivering the same amount of power for about one-half of the weight.

Responsibility for a cesium 137-fueled, 5-watt thermoelectric generator which had been under development for the Commission's Division of Isotopes Development was this year transferred to the Division of Reactor Development. The unit, developed by Royal Research Corp., will be delivered next year to the Lamont Geological Observatory of Columbia University. It is to be placed on the floor of the Atlantic Ocean to transmit data on earth tremor frequencies and distribution.



Compact SNAP–2. About the size of a five-gallon can and weighing about 200 pounds without shielding, the compact SNAP–2 reactor will provide three electrical kilowatts of power for use in satellites. Fission heat from the uranium-zirconium hydride alloy fuel in the reactor will be transferred, by a liquid sodium-potassium (NaK) coolant, to a boiler superheater containing mercury. As the mercury boils, its vapor will be used to drive the turbine of the Combined Rotating Unit in which the electricity-producing alternator, the NaK pump, and the mercury pump are all mounted on a single shaft within a hermetically-sealed housing. The drawing shows the major components of the system which has been developed for the Commission by Atomics International.

Snap Reactor Projects

Although power levels of the order of tens and hundreds of watts are possible with the radioisotope-fueled generators, the still higher powers needed for advanced missions—the kilowatts and eventually megawatts of power—will require the use of nuclear reactors.

To produce the electrical energy for missions which require larger amounts of power—manned space stations, bases on planets, large communications satellites for FM and television, for example—small nuclear reactors can serve as the heat source.

Theoretically, the fissioning of one pound of uranium 235 will produce about 10 billion watt-hours of heat. Through the use of a thermoelectric converter or a turbogenerator, part of this tremendous storehouse of energy can be made available. The rate will be dependent

upon the means of conversion. Approximately 500 thousand kilowatt-hours of electricity are actually available for each pound of uranium consumed.

TABLE 2.—STATUS OF SNAP REACTOR UNITS

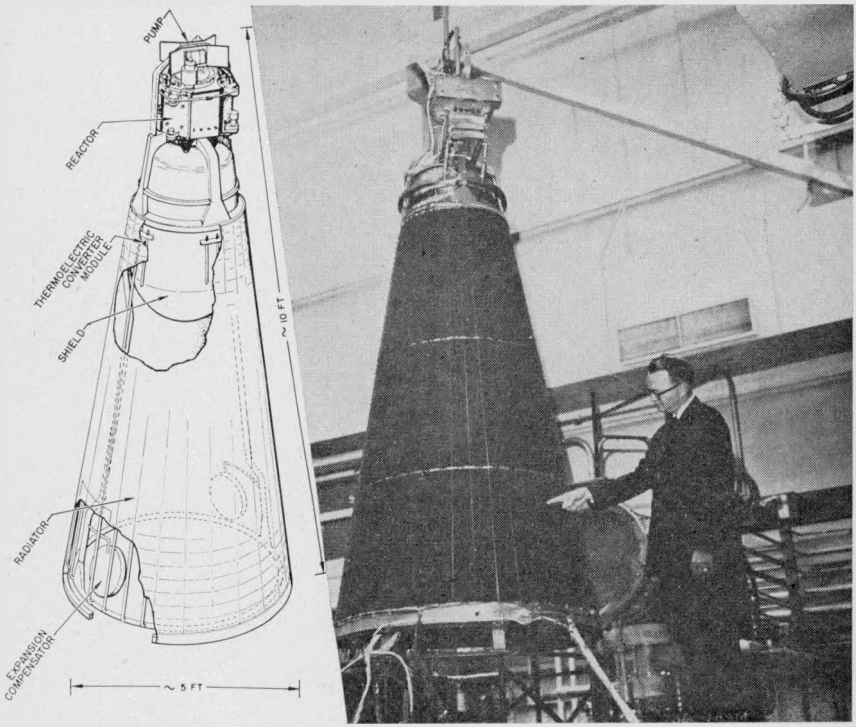
November 1962

SNAP No.	Power electrical (kilowatts)	Life (years)	Application	Fuel	Status
2	3	1	Potential use in AF satellite.	Uranium zirconium hydride.	Joint AEC–AF program—1965 orbital flight tests.
8	30–60	1	Ion propulsion, electrical power and space communications.	Uranium zirconium hydride.	Flight test 1966.
10–A	.5	1	Potential use in AF satellite.	Uranium zirconium hydride.	Joint AEC–AF program—1964 orbital flight test.
50	300–1,000	1	Ion propulsion, communication satellites, space electrical power.	Not determined	Research and development—design.

Reactor Devices

Several SNAP reactor systems are being developed for the Commission by Atomics International at its Canoga Park, Calif., facility; none as yet has become fully operational. The smallest of the systems is designed to provide 500 watts of electricity and be capable of continuous operation for 1 year or more.

SNAP 2.—One of the SNAP reactor systems, SNAP–2, is a very compact, 3 electrical kilowatt reactor-turboelectric system for space applications. The reactor is approximately the size of a 5-gallon container, weighs about 200 pounds without shielding, and is fueled with a uranium-zirconium hydride alloy. Heat from the reactor is transferred by a liquid sodium-potassium (NaK) coolant to a boiler-superheater containing mercury. As the mercury is boiled, its vapor drives the turbine of the Combined Rotating Unit (CRU) which has the alternator, the NaK pump, and the mercury pump all mounted on a single shaft enclosed in a hermetically sealed casing. Direct condensation of mercury vapor in the radiator-condenser provides for elimination of waste heat. The design of the CRU, the most critical component in the power conversion system, was completed, and mass simulation and thermal and environmental tests of developmental system mockups were carried out in 1962. Fabrication and qualification testing of flight systems will be initiated in 1963.



First Reactor Into Space. The SNAP–10A reactor, which will produce 500 watts of auxiliary for equipment and instrumentation in space vehicles and satellites, is expected to be launched during 1964. When a safe orbit has been achieved, the nuclear reactor will be started by a radio command from earth to provide power for an Air Force satellite. It will be the first reactor-type SNAP (Systems for Nuclear Auxiliary Power) unit to be used in space. Photo, *right*, shows a mock-up of the SNAP–10A atop a satellite nose cone. Drawing, *left*, shows the major components of the 750-pound unit which was developed for the Commission by Atomics International. The reactor will have a 30 kilowatt heat output—from the fissioning of the uranium-zirconium hydride fuel—which will be drawn off by a sodium-potassium liquid metal coolant which, in turn, will pass over thermoelectric elements where the heat will be converted into electricity. The cold end of the thermoelectric converter will be cooled by heat radiating to space through the finned radiators. The system is currently undergoing rigorous environmental and performance tests.

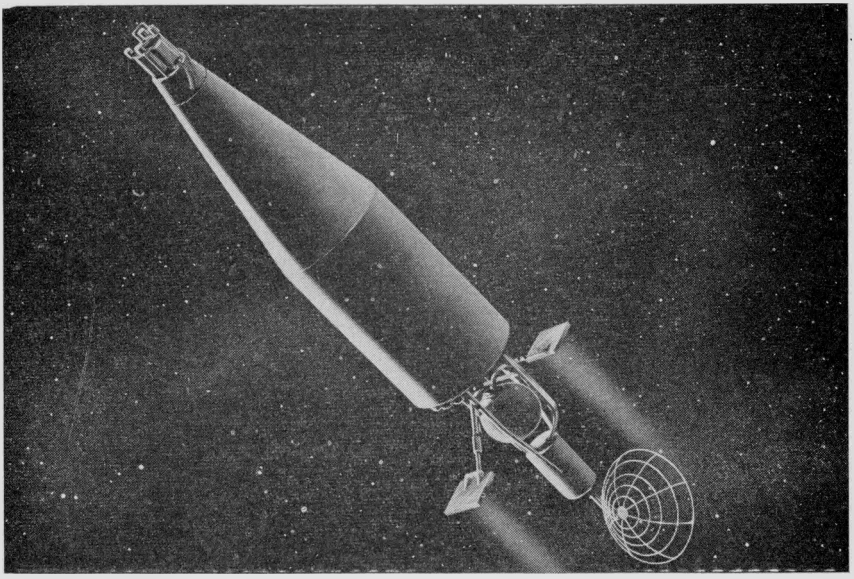
SNAP–10A.—Designed to produce 500 electrical watts, the SNAP–10A system is a SNAP–2-type reactor coupled to a combined thermoelectric converter-radiator. The system is basically composed of three components—the reactor in the center, a cylindrical shell containing the thermoelectric converter, and the directly attached radiator. The heat produced by the fissioning of the uranium-zirconium hydride fuel in the reactor is transferred by a NaK coolant loop to the thermo-

electric converter. The cold end of the thermoelectric converter is cooled by heat radiating to space through finned radiators. The first nonnuclear flight system mockup was essentially completed in 1962 preparatory to extensive environmental and performance testing in early 1963. Progress was made toward completion of the first nuclear flight system ground test to begin qualification and endurance testing in late 1963.

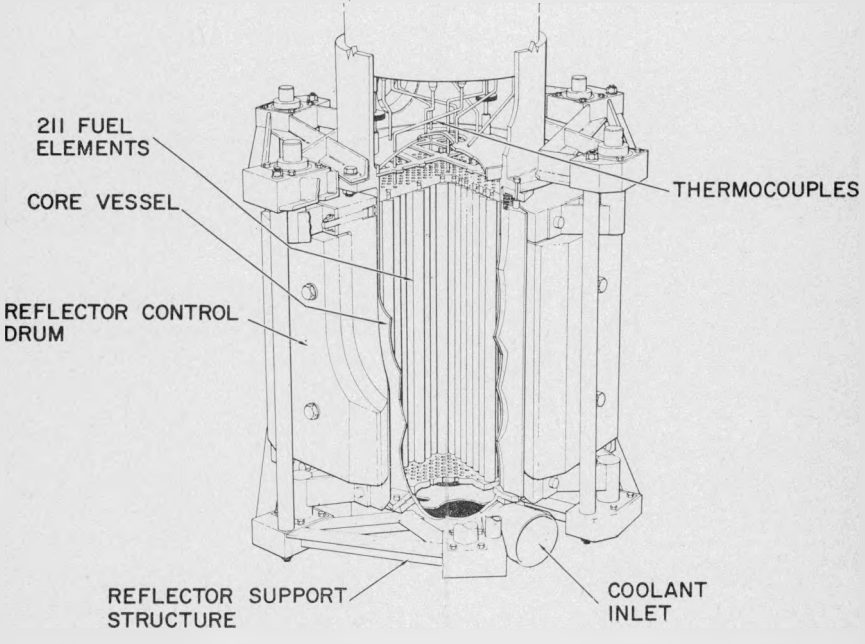
SNAP–8.—The SNAP–2 and SNAP–10A systems provide only limited electric power—3 kilowatts or 500 watts electric. To extend the uranium-zirconium-hydride technology to higher power and temperature limits, the SNAP–8 system is being developed as a joint effort by the AEC and NASA. It will include a 600-kilowatt (thermal) reactor developed by AEC and a 30 kilowatt electrical generating system developed by NASA. This reactor is a scale-up of the SNAP–2 reactor (by a factor of 10) which utilizes the uranium-zirconium hydride concept. It is slightly larger than SNAP–2 because of the heat transfer and burnup requirements of the higher thermal power output. The performance of SNAP–8 is improved over that of SNAP–2 by an increased reactor outlet temperature and a higher in-core temperature. The first developmental power reactor of the SNAP–8 family, the SNAP–8 Experimental Reactor, was completed and achieved criticality in September. It will test the capability of the SNAP–8 system to produce the power required. Initial operation of this reactor will begin in early 1963 with power operation testing reaching completion in late 1963. All power generated by this reactor will be removed by a waste heat dissipation system.

SNAP–4.—The SNAP–4 concept is directed toward developing a nuclear turboelectric plant using uranium-zirconium hydride fuel with water coolant and working fluid for unattended operation in remote terrestrial locations or underwater. The current design is based on a 2-electrical-megawatt plant with a 1-year life. A SNAP–4 critical experiment has been successfully tested and fuel elements have been fabricated and subjected to 1 ma/o burnup.

Flight tests.—Each of these SNAP reactor systems must satisfactorily undergo extensive testing to insure its reliability and safety. Present schedules contemplate that the first of the reactor-electric power units, SNAP–10A, will be ready in the 1963–64 time period to be assembled to an Air Force Atlas-Agena satellite vehicle and launched into orbit. When a safe orbit is achieved, the reactor will be started by radio command to supply electricity to the Air Force's equipment on board the satellite. Flight testing of the other SNAP reactor systems now under development will follow in the 1965–68 time period.



For Interplanetary Travel. Scheduled for flight test in the late 1960's, the SNAP–8 (Systems for Nuclear Auxiliary Power) is being developed as a potential power source for interplanetary travel as a joint AEC–NASA project. The SNAP–8 nuclear reactor system will produce 30 kilowatts of electricity using one generator unit or 60 kilowatts with two units coupled to the same reactor. *Drawing above* shows the SNAP–8 (*upper left*) concept as it might be used for power in an ion propulsion space vehicle. Drawing *below* shows the major parts of the 600 thermal kilowatt SNAP–8 reactor which is a scaled-up version of the SNAP–2. The reactor is being developed for the Commission by Atomics International.



ADVANCED SNAP SYSTEMS

Since larger and larger energy sources will be required as time goes by, the development of a new technology is mandatory. A whole new family of materials must be developed which will operate successfully at extreme temperatures. Distortion-free reactor fuels, more efficient coolants, lightweight structural materials—all require, and are being given, expanded research. An integral part of the SNAP program is the development of advanced methods and devices for converting heat—either radioisotope-decay-produced or reactor-produced—into electricity; new techniques leading to more efficient conversion are being studied.

SNAP–50

The initial system to utilize the new high temperature structural materials, coolants and reactor fuels discussed above was initiated this year—the SNAP–50 program. The first phase of this effort includes program planning, preliminary reactor and primary system design, fuel and component development. The SNAP–50 is a joint AEC-NASA-DOD project. During 1962, agreement was reached making the AEC responsible for development of the reactor and the necessary power conversion unit.

The basic technology for the program is provided by the high temperature lithium cooled reactor which has been under development by Pratt & Whitney at CANEL (Connecticut Advanced Nuclear Engineering Laboratory) in Middletown, Conn., since 1958. This project was formerly under the Aircraft Nuclear Propulsion (ANP) program. The technology for the SNAP–50 will be demonstrated in the lithium cooled reactor experiment (LCRE) scheduled for operation at the NRTS in Idaho during 1965.

Objective of the SNAP–50 program is to develop and provide the advanced technology for a power plant operating in the space environment and having an electrical output in the power range of 300 kilowatts to 1 megawatt. The power plant will be a Rankine turboelectric system which, by virtue of its high temperature operation and resultant compactness coupled with a long life design requirement, will have unique potential for satisfying many advanced space power requirements. The power plant will be configured compatible with the space boosters and vehicles planned during its operational time period. Under a vigorous development program, a prototype system is expected to be available for flight test in the late 1960's or early 1970's.

In addition to industrial contractors, the National Laboratories

are being utilized in the advanced SNAP programs. Oak Ridge National Laboratory has been assigned the role of supporting laboratory for the SNAP–50 program and Argonne National Laboratory has the "in-house" responsibility for exploratory research and analysis work leading to even higher power systems. A major part of the Oak Ridge effort in the advanced space power field is directed toward a medium power reactor experiment (MPRE). The MPRE is a direct cycle liquid metal boiling reactor with a power output potential of the order of 100–300 electrical kilowatts.

NAVAL REACTORS PROGRAM

The Naval reactors program has as its primary objectives (*a*) the development of advanced nuclear propulsion plants ranging in size and power rating from plants for small submarines to reactor plants for large surface ships, and (*b*) the development of improved reactor cores and components with significantly longer lifetimes which will result in fewer refuelings, lower fuel costs, and less out-of-service time for naval ships. The technological advances brought about through the Naval reactors program also contribute to the advancement of civilian and other military reactor technology.

The development of nuclear reactors—no matter what their final application—is intricate, laborious, and exacting. The difficulty of development is increased when the nuclear reactor must be designed to power naval warships operating in a rigorous sea environment. Nuclear ships must be able to travel long distances independent of shore-based maintenance and supply support. Each part of a naval nuclear reactor, from simple "nuts and bolts" to large, complex components like pumps and control panels, must be exhaustively tested for feasibility, reliability, performance, and endurance to assure that it will do its intended job. To test, study, and improve nuclear reactor systems and components of unproven performance before they are operated in a naval ship, land-based prototype plants are built which simulate the environment in which the reactor must operate.

Land Based Prototypes

Six of these land-based prototype plants in which various reactor plant systems cores and associated components are developed and tested for specific shipboard applications have been authorized under the Naval reactors program.

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Varied Sizes

Three prototypes—the *Submarine Advanced Reactor* (*S3G*),[12] the *S1W Reactor Facility*, and the *Small Submarine Reactor* (*S1C*) are operating in support of development work for improved cores and components for nuclear propulsion plants for submarines of various sizes and power ratings. Analysis and evaluation of data derived from operation of the *Large Ship Reactor* (*A1W*) land-based prototype plant are performed in support of reactors and propulsion systems for surface ships such as those installed in the nuclear aircraft carrier *Enterprise* and the nuclear cruiser *Long Beach*.

Initial criticality of the *Destroyer-type* (*Frigate*) *Dual Reactor* (*D1G*) was achieved in March, and the reactor first operated at 100 percent power on May 9. D1G plant operation and testing is continuing to determine performance characteristics and to evaluate plant design of the Navy's first nuclear-powered guided missile destroyer leader, the *Bainbridge*.

Natural Circulation Concept

Construction of the sixth prototype, the *Natural Circulation Reactor* (*S5G*), is scheduled for completion in 1964. Since the most difficult problem in the development of a reactor which uses natural convection to circulate the reactor cooling water is to insure that the plant will operate satisfactorily under severe conditions of ship motion, this prototype has been designed to simulate the ship motions the reactor will experience at sea.

During the coming year, the Naval Reactors Program will continue to direct major effort toward the development of higher-power, longer-life cores; an improved submarine propulsion plant (S5G); and an advanced plant for surface ships (D1W). Work on the D1W single-reactor destroyer plant includes development of the largest and highest power reactor core yet designed for the Naval reactors program.

Nuclear Fleet

The December 31 status of all 80 of the nuclear-powered ships which the Congress has, to date, authorized under the Naval Reactors Program is shown in Part II, Section B, of the table in Appendix 7.

[12] In the symbols used to designate Naval reactor projects, the first character specifies ship type (S=submarine, D=destroyer, A=aircraft carrier, etc.); the second number is the sequence number of the plant design; the third character designates the name of the contractor responsible for the design of the reactor plant (W=Westinghouse, G=General Electric, etc.).

At year's end, the U.S. Navy had in operation 28 nuclear-powered submarines as well as 3 nuclear-propelled surface ships, i.e., the 2-reactor-powered cruiser *Long Beach*, the 8-reactor-powered aircraft carrier *Enterprise*, and the 2-reactor-powered guided missile destroyer leader (frigate) *Bainbridge*.

ARMY REACTORS PROGRAM

The Army reactors program has as its primary objectives (*a*) the development of a series of nuclear power plants which will alleviate the serious conventional fuel logistics problems encountered at remote military installations, and (*b*) the development of high performance mobile nuclear power plants which can be used by the military services under combat conditions.

Military installations must necessarily be located in a variety of locations and environments. In populated areas which are regularly serviced by utility companies and communication routes, there is no greater problem in supplying support services to military installations than there is to supplying such services to the local citizenry. In remote areas, however, no local services are available, and all support facilities must be "carried on the back" of the installation. The development of nuclear reactors which are relatively small in size, relatively light in weight, transportable, readily assembled and disassembled, and are capable of satisfying all the power and heat requirements of the installation, will obviously be a great step forward for the military services. Reactors built, being built, or planned under this program are listed in Appendix 7.

Types of Reactors

The Army reactors program has, to date, developed and put into operation nuclear reactors of differing mobility: stationary reactors—those which are not designed for subsequent relocation, and are generally located at major military installations needing substantial blocks of power independent of conventional fuel supply; portable reactors—those which are capable of being moved in packages and reassembled for stationary operation, and are developed primarily for use in remote locations; and mobile reactors—those which are capable of being moved intact, or virtually intact (on a truck bed or in an airplane, for instance), and are for use in direct support of military field operations.

STATIONARY REACTORS

SM–1 and SM–1A

Of the stationary reactors developed under the Army reactors program, the pressurized water SM–1 [13] at Fort Belvoir, Va., has been, and is continuing to be, used by the Army for performing research and development work in support of field plants and for training military personnel to operate reactors. The plant has been in operation since 1957, generating about 1,855 kilowatts of electricity for use in normal port operations at Ft. Belvoir. It is not used to provide space heat. The SM–1, built in 1957 by Alco Products under a Commission contract, is the Army's oldest reactor.

The *SM–1A*, an Army-funded field plant patterned after the SM–1 prototype, attained full power operation on April 17. The plant is providing 1,640 kilowatts of electric power and 46 million Btu's per hour of steam for space heat to the U.S. Army's Arctic Test Center at Fort Greely, Alaska.

The SL–1

The Commission's Board of Investigation which had been appointed to seek out the cause of the January 3, 1961, accident to the *SL–1* reactor made its final report during September 1962. The Board found the cause to be withdrawal of the central control rod by one or more members of the three-man maintenance crew which were preparing the reactor for return to operation. Cause for the control rod withdrawal is not known. Prior to the Board's findings, the reactor had been dismantled and the core examined and put through a series of tests to determine whether a mechanical or nuclear malfunction may have caused the accident. The Board's final report is included in this report as Appendix 8.

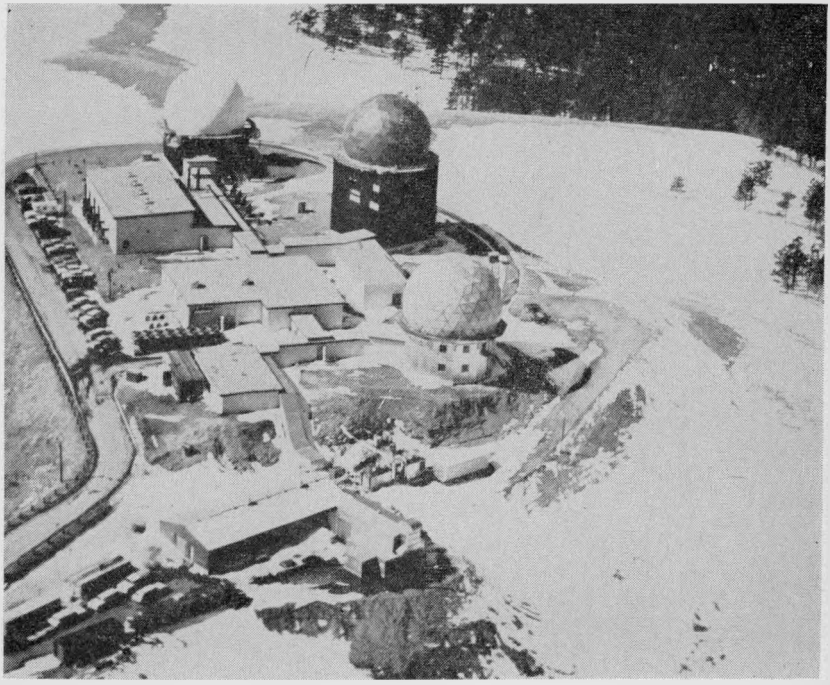
The SL–1 was a boiling water plant constructed as an Army prototype facility at the AEC's National Reactor Testing Station in Idaho. It was a stationary low power plant, designed by Argonne National Laboratory to provide 400 kilowatts equivalent space heat and 200 kilowatts of electricity at small remote military installations. It had been in test operation for two years prior to the accident in which three men were killed, the first fatal incident in the history of U.S. reactor operation.

[13] In the symbols used to designate Army reactors project, the first character indicates mobility characteristics (S=stationary; P=portable; M=mobile); the second character indicates power range (L=low, 100–1,000 electrical kilowatts; M=medium, 1,000–10,000 ekw; H=high, 10,000 ekw or more); the third number indicates the order in which plants having the same mobility and power characteristics are initiated; the fourth character shows alphabetical order in which field plants of a specific type are initiated.

PORTABLE REACTORS

PM Series

Wyoming.—The *PM–1*, a 1,000 electrical kilowatt pressurized water reactor located at Sundance, Wyo., attained initial criticality on February 25, 1962. The first power was delivered to Sundance radar site in April 1962. Performance testing was completed and the plant transferred to the Air Force October 31, 1962. A total of 881,000 kilowatts of electricity had been produced prior to transfer. The plant is now the principal source of electrical power and space heat for the Sundance Air Force Station radar site. The PM–1 reactor was built by Martin-Marietta Corp.



PM–1. Photo shows the PM–1 nuclear power plant and radar installation at Sundance, Wyo. The PM–1 can supply 1,000 kilowatts of high quality electrical power required to operate the U.S. Air Force Sundance Radar Station, and can also provide 7,000,000 BTU per hour of steam for space heating. On February 25, 1962, the PM–1 achieved initial criticality. The PM–1 was transferred to the U.S. Air Force on October 31, 1962. The buildings housing the pressurized water PM–1 reactor are in the lower left of the photo. The reactor plant is modular in nature and after being assembled at the Martin-Marietta Corp. plant in Baltimore, Md., was broken down and transported—by plane and truck—to the Sundance site.

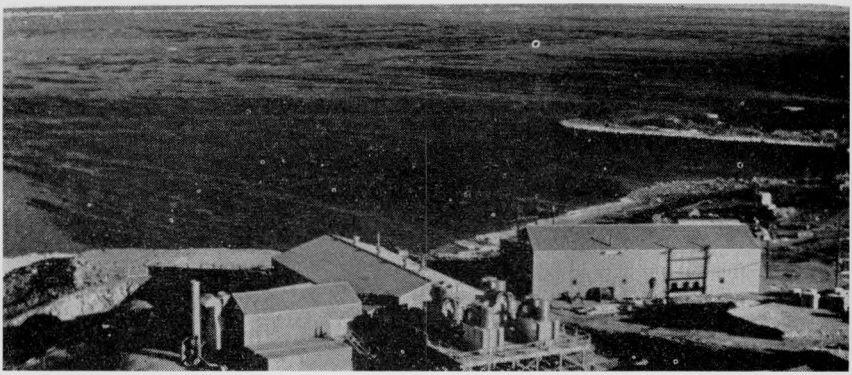
Greenland.—The *PM–2A* at Camp Century, Greenland, a pressurized water reactor plant and the first prefabricated, packaged facility to be put in operation, is continuing to generate electricity and melt snow at an under-ice Army base only 886 miles from the North Pole. The plant went into operation in November 1960. It produces 1,500 kilowatts of electricity and 1 million Btu's per hour of steam for melting snow for the base water supply.

Antarctica.—The pressurized water *PM–3A* was shipped to McMurdo Sound, Antarctica, during December 1961 and began furnishing 1,500 kilowatts of electricity to the principal support base for all U.S. scientific activity in the Antarctica during 1962. The reactor went critical on March 4. The Martin-Marietta-fabricated PM–3A was reassembled at the site by Navy Seabees and was able to sustain a chain reaction within 80 days after the ship carrying it arrived at McMurdo Sound. The PM–3A has also been used to melt snow for the camp's water supply. However, the Navy is installing a multistage, flash-type water conversion system which will use process steam from the nuclear power plant, thus making it the first nuclear plant to provide heat for desalination.

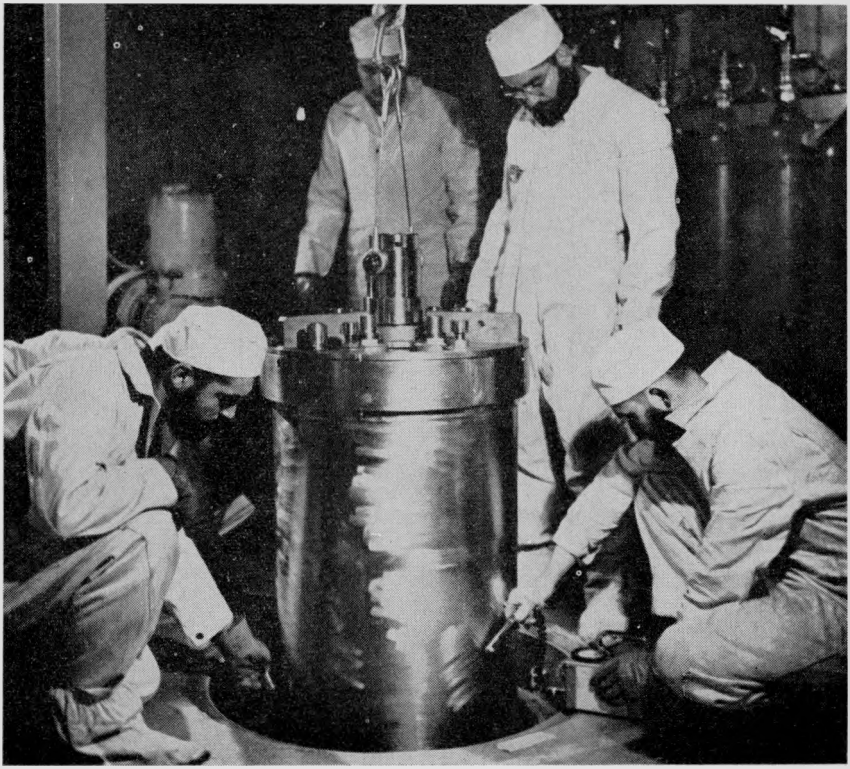
On October 7, a small flash fire occurred in the reactor containment tanks and caused minor damage. No personnel were injured and no radiation was released. The plant was restored to an operable status and modified to prevent recurrence of a similar incident. Based on AEC review of the plant and procedure modification, resumption of PM–3A operation was authorized on November 8 and the plant commenced operation on November 9. Since that date, five additional shutdowns have been necessary because of apparent increases in the hydrogen concentration within the containment. Studies are in progress to determine the best permanent means for maintaining the hydrogen concentration in the vapor containment at less than 50 percent of the minimum combustible limit.

After a shutdown on November 26 because of indicated high hydrogen concentration, containment was purged to reduce hydrogen concentration and the plant was restarted on November 27. However, when it was found that the rod bank positions for critical and power operation were higher than previous rod positions by more than 1 inch the plant was again shut down and cooldown initiated so the control rod actuator could be inspected. Depending on the condition of the control rod actuator mechanism, the plant might have to remain inoperative until spare parts can be obtained.

A plant shutdown had been scheduled for December and part of January to allow contractor correction of plant deficiencies which have become apparent since plant operations were initiated. After com-



PM–3A. Photo *above* shows the PM–3A nuclear power plant located on the western slope of Observation Hill, southeast of the U.S. Navy McMurdo Base Camp in Antarctica. The PM–3A, the first nuclear power plant on the Antarctic continent, achieved initial criticality on March 3, 1962. Photo *below* shows the reactor being emplaced at its Antarctic site by Navy Seabees. The PM–3A can provide the base with 1,500 kilowatts of electricity and 650,000 BTU per hour in the form of steam which has been used for space heating and the melting of snow to provide water for the base. Following a small flash fire in October the plant has operated intermittently because of technical difficulties and at year's end it was shut down while a Martin-Marietta Corp. crew corrected the plant's deficiencies.



pletion of this work, a 400-hour plant endurance run is scheduled prior to AEC acceptance of the facility.

PM–3B Project Cancelled

The PM–3B plant, originally designated PL–3, was to have been shipped upon its completion in 1963 to the Byrd inland Antarctic station to supply electric power and steam to an ice-tunnel installation used by the National Science Foundation in scientific studies and by the Navy for support activities. A contract for the design, fabrication, installation, and test operation of the PL–3 had been awarded Alco Products, Inc., Schenectady, N.Y., in October of 1961. During 1962, however, Alco Products discontinued its nuclear operations. The task of completing the project, redesignated the PM–3B, was assigned in June to the Allis-Chalmers Manufacturing Co., who continued the operation of the Alco facilities in Schenectady. On October 2, the PM–3B contract with Allis-Chalmers was terminated by the AEC because of cost increases, schedule slippages, and particularly because the original design as developed did not adequately meet the original objectives for a lightweight, readily transportable and installable power reactor for use at such remote locations and rigorous environments.

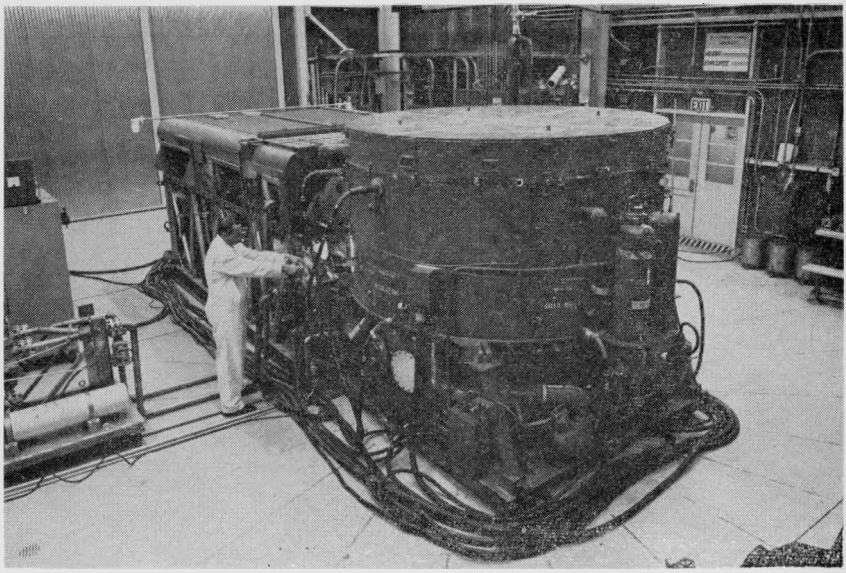
Coincident with cancellation of the PM–3B contract, Allis-Chalmers submitted a proposal for reanalyzing the design of the reactor, recommending areas where redesign might effect improvements, and performing such redesign work as the AEC approves. Allis-Chalmers was authorized to proceed with a first phase of this effort as of October 15. Recommendations for design improvements resulting from this effort were submitted in mid-December, and the contractor is now proceeding with the approved redesign efforts.

MOBILE REACTORS

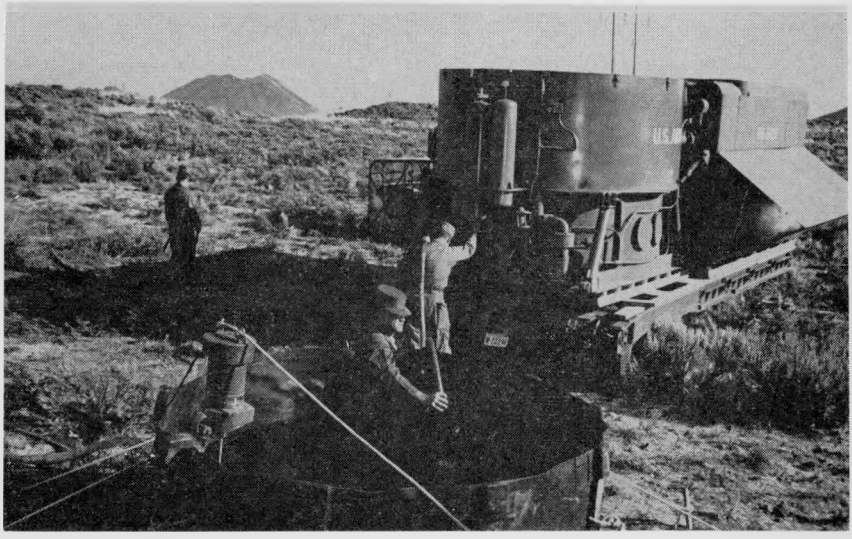
The ML–1

The Army reactors mobile plant—designated the *ML–1*—is a prototype plant of particularly novel design. It is the world's first direct- and closed-cycle gas-cooled nuclear power system. The gas heated in the reactor core is used to drive a turbine to produce electricity, and then returned to the core. It produced its first power during September.

The nuclear power plant consists of three basic "packages"—one package contains the 15-ton reactor, another contains the 3-ton transistorized control cab, and the third contains the 15 tons of machinery and equipment which converts the hot reactor outlet gas into elec-



Mobile Plant. On September 21, 1962, the ML–1 (Mobile Low Power Reactor No. 1) with its interconnecting power conversion unit generated its first electricity at the National Reactor Testing Station. Built for the Commission's Army reactors program by Aerojet General Nucleonics, the three-unit plant is the first mobile nuclear power plant for support of the Army in the field. Photo *above* shows the 15-ton gas-cooled reactor (*right*) and the 300–500 electrical kilowatt generator (*left*) just prior to the first power run. The third unit, the control cab, is partially visible on the left. Each of the units is mounted on skids so that the plant can be transported by trailer truck. Photo *below* shows a mockup of the plant, mounted on a low bed trailer, being used for training troops in its operation under field conditions.



tricity. (Four additional auxiliary packages bring the total plant weight to 40 tons.) Each package is mounted on skids which can be transported by standard aircraft, truck-trailer, train, barge, ship, or sled to wherever it is needed. The three main skids can be coupled together and the assembly placed in full power—300 to 500 electrical kilowatts—operation 12 hours after arrival at its destination. The three-part power plant can be disjoined and be readied for movement to a new location 24 hours after it is shut down.

Although designed with a military use in mind, the mobility of the plant also makes it a likely candidate for use in disaster areas where conventionally-fueled power plant service is either not available or will be out of service for a substantial period of time.

Self-sustained operation of the entire plant was achieved on September 20. Testing will be continued to determine performance characteristics. Prime contractor for ML–1 development is the Aerojet-General Corp. of Azusa, Calif.

The MH–1A

Another Army reactors mobile nuclear power plant which is currently in the design stage, the MH–1A, is to be a floating power plant which can be towed to ports or coastal facilities to supply electrical power to remote military installations or to disaster areas where normal power supplies are interrupted. The reactor is to be installed in the hull of a modified and reconditioned surplus Liberty ship. Conversion of the carrier ship and actual installation of the nuclear power plant into its hull is scheduled to be completed by 1965. This is an Army-funded project with the Martin-Marietta Corp., Baltimore, as the contractor.

COMPACT REACTOR

The Commission's Army reactors program, in response to a Department of Defense requirement, has undertaken development of a prototype Military Compact Reactor (MCR). The MCR is to be a reactor of very small size which can be used for furnishing 3,000 kilowatts of electric power to the troops in the field, can be started quickly, shut down and moved and restarted quickly—quickly in this case meaning within a period of a few hours. Such a reactor is expected to materially reduce the burden which the shipment and storage of petroleum imposes on combat forces. In November, a contract was awarded to General Motors Corp., Allison Division, Indianapolis, Ind., as prime contractor, and United Nuclear Corp., White Plains, N.Y.,

as principal nuclear associate, for the development, fabrication, and testing of an operating prototype of such a mobile field powerplant.

ASSOCIATED WORK

Mobile Energy Depot System

The Nuclear Power Energy Depot, now under feasibility study, would use a nuclear reactor to power chemical fuel synthesis plants or to regenerate other systems as a step towards reduction of military logistical requirements for hydrocarbon fuels. The purpose of the Army-funded studies by Allison Division of General Motors Corp., Indianapolis, Ind., and Allis-Chalmers Manufacturing Co., Milwaukee, Wis., is to investigate and evaluate the technical feasibility of various methods by which the energy produced by a mobile nuclear reactor could be converted in form and stored for later use to meet the requirements for small packages of energy. Chemical fuel or rechargeable secondary batteries could then be used for vehicle propulsion or in mobile equipment to furnish electrical power.

Possible fuels. As a continuation of the Energy Depot System feasibility studies the Commission, through its New York Operations Office, invited proposals for the study of mobile water electrolysis units on November 16.

The two original studies conducted by Allis-Chalmers and General Motors identified hydrogen and ammonia as possible chemical fuels for use in the Energy Depot concept.

Readily available in water and air, these fuels can be manufactured in the field and ultimately used for vehicle propulsion and other military power source requirements. One of the keys to the eventual use of these fuels is the development of lightweight, rugged, mobile electrolysis units for their manufacture.

"Standard" Core

Intensified effort will be given to designing and developing a "standard" core which can be used not only in future medium-power-level pressurized water reactor plants but can also be used as replacement cores for existing plants. The development of the "standard" core is being accomplished by the Martin-Marietta Corp., at Baltimore, Md.

REACTOR SAFETY PROGRAM

A high degree of safety has been achieved in the U.S. reactor development program through close attention to safety in reactor system design, construction, operation, and maintenance.

A continuing and expanding effort to minimize the probability of occurrence of a significant nuclear accident has been carried out since the inception of the U.S. atomic energy program, particularly with regard to reactor development. The combined use of accident-prevention safeguards (*e.g.*, high inherent safety in core design, fail-safe control systems, safe operating practices) and consequence-limiting safeguards (*e.g.*, distance and isolation area, multiple-barrier containment of radioactivity, spray washdown systems) have been employed. These safeguard measures invariably increase the cost and complexity of reactor facilities, and it is desirable to ascertain their respective incremental contributions to overall reactor system safety. This requires a coordinated research and development effort.

Safety Research and Development

The Commission's Division of Reactor Development is sponsoring a wide variety of programs in various areas of nuclear safety.[14] All of them have as their primary objectives the development of essential relevant engineering data and information to provide a sound basis for locating nuclear facilities, for the design of safe reactors, and for the safe operation of nuclear systems. Some of these programs are of long-standing, such as waste management; some are of more recent origin, such as aerospace safety tests; some are yet in the planning stage, such as large-core reactor safety studies.

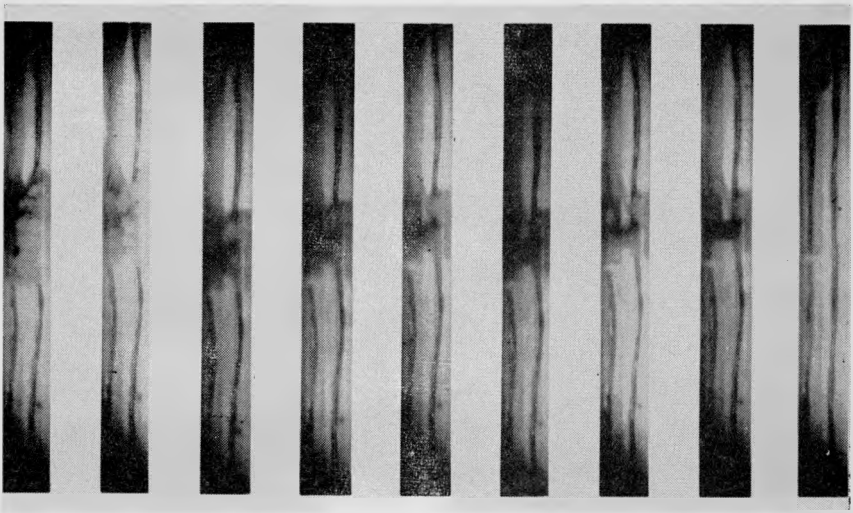
The major areas covered by the nuclear safety research and development program are (*a*) reactor safety research and development, (*b*) engineering field tests, and (*c*) effluent control research and development.

REACTOR SAFETY RESEARCH AND DEVELOPMENT

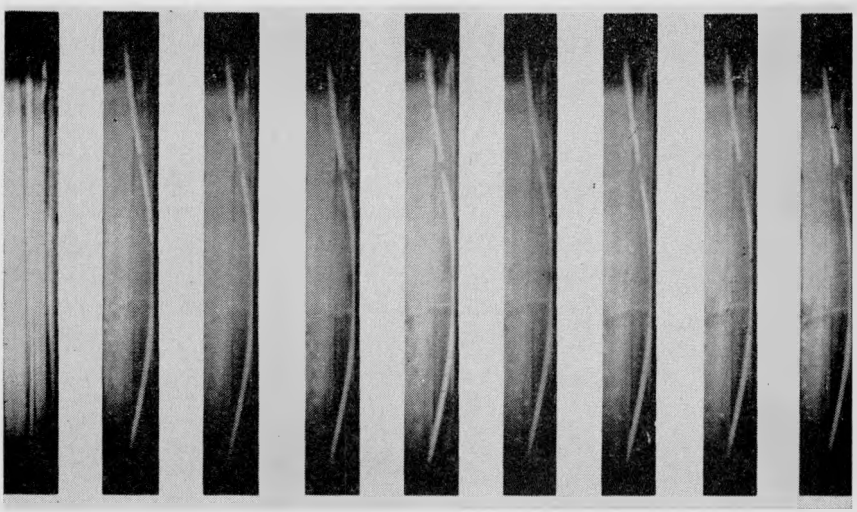
SPERT Tests

The *SPERT* (Special Power Excursion Reactor Tests) program, sponsored by the Commission investigates nuclear reactor safety, particularly the kinetic response of reactors to large reactivity perturba-

[14] Much of the work summarized here is more fully discussed in the supplementary report, "Fundamental Nuclear Energy Research—1962".



Fuel Failure. Using high-speed photography, Argonne National Laboratory has been studying the causes and mechanics of fuel meltdown, a conceivable situation which could lead to reassembly of the fuel in a super-critical assembly. The *above* is a sequence showing failure of an Experimental Breeder Reactor–2 (EBR–2) element, from a color film exposed at 3,900 frames/second. Two samples can be seen in the first photo taken before failure: The one on the *left* is the direct view of the sample, the one on the *right* is its image in a mirror. The second photo shows sample at onset of failure, with the characteristic warpage which occurs as the sample approaches failure temperatures. Subsequent pictures give the early development of failure and cloud of sodium originally present in the element as a thermal bond between fuel and cladding. *Below,* the sequence of prints shows failure of an Enrico Fermi Fast Reactor (EFFR) element, from a film exposed at 1,325 frames/second. The first picture shows the undamaged sample and its image just before heating. Remaining photos show the element sagging against the container wall and molten uranium streaming out of a small failure.



tions of the type usually postulated for accidents. It is planned and carried out for the AEC by Phillips Petroleum Co.

The *SPERT* facilities, located at the National Reactor Testing Station in Idaho, include a simple, open tank-type, reactor (*SPERT–1*); a D_2O-moderated medium-pressure reactor (*SPERT–2*); a full-scale pressurized-water system (*SPERT–3*); and a large pool-type reactor (*SPERT–4*), providing flexibility for testing a number of reactor types and sizes [15]

SPERT–1

Early in 1962, a highly enriched, plate-type, aluminum-clad core was loaded into *SPERT–1* in preparation for a "destructive test" program which began in October. Static measurements were made to determine nuclear parameters of the core, measure flux, and calibrate instruments.

During April, transient tests with self-limiting excursions were conducted to learn the basic transient properties of the core and to obtain data for extrapolation into the region where destructive tests could be expected. The periods of these tests were progressively shortened from 934 milliseconds (msec) to about 7 msec, at which point minor fuel plate deformation occurred. In May and June, tests with still shorter periods were made. In the two shortest, 5 and 4.6 msec, some melting of fuel plates occurred. At this point, a detailed inspection was made of the core, data were analyzed, and final preparations were begun.

The actual destructive test series began on October 24, and terminated November 5, 1962, with an excursion period of 3.3 msec, in which the reactor was destroyed. Detailed studies of the data, photographic records, and radiation measurements were expected to yield quantitative information that was lacking in the BORAX–1 destructive test of July 1954.

SPERT–2

In *SPERT–2*, kinetics tests were performed on a highly enriched aluminum-clad plate-type core with heavy water (D_2O) as the coolant and moderator. It was observed that the peak power and the energy release during excursion tests with the D_2O system were significantly higher than those observed for tests with light water systems. It was

[15] More details are given in the AEC reports, "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Management—1961" ($2.25), "Annual Report to Congress—1961" ($1.75), and "Fundamental Nuclear Energy Research—1962"; available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

also noted that the threshold at which limited mechanical damage to fuel assemblies is encountered occurs in the D_2O system for excursions with reactor periods approximately 10 times longer than for the light water systems, *i.e.*, approximately 70-msec-period tests in D_2O vs. approximately 7-msec-period tests in light water (H_2O). Also it takes about 10 times greater reactivity insertion per given reactor period.

SPERT–3

The reactor was out of operation during 1962, awaiting replacement of a pressurizer vessel which failed October 26, 1961.

SPERT–4

The *SPERT–4* facility, completed in September 1961, received approval for operation in July 1962. Instability studies on high enrichment plate-type cores were initiated in 1962. Instability phenomena were first discovered in SPERT–1 but, because of the small size of the reactor tank in SPERT–1, these studies could not be performed effectively. SPERT–4 has two large pool-type tanks and is capable of stability studies on large cores.

Fast Reactor Safety

During the year, Argonne National Laboratory continued in-pile experiments on fast reactor fuel samples using the Transient Reactor Test (TREAT) facility at NRTS. Principal basis for the program is the study of fuel meltdown, a situation which could conceivably occur and lead to reassembly of fuel into a supercritical assembly. Previous studies on failure conditions and modes of failure of Experimental Breeder Reactor–2 (EBR–2) samples were extended to include effects of a stagnant sodium environment on failure and fuel movement, element-element interactions in uncooled clusters, and a qualitative survey of capability of an EBR–2 subassembly shell to contain molten fuel under hypothetical loss of coolant accident conditions.

Newly developed photographic meltdown facilities were used to observe failure and fuel velocity characteristics of single EBR–2 and Enrico Fermi Fast Reactor samples in the absence of sodium. In addition, EBR–2 size uranium oxide samples clad with steel, niobium, or tantalum were exposed in TREAT in order to study clad containment capabilities, mechanisms of failure, and oxide behavior under transient heating. The first survey experiments were performed on EBR–2 samples previously irradiated to appreciable fission product

inventories, as part of a program to study effects of fuel irradiation on failure and fuel movement.

Engineering Field Tests

The programs in nuclear safety engineering field testing were initiated in the fall of 1961 to provide model prototype and engineering-scale field tests to proof-test or demonstrate the safety and reliability of terrestrial and aerospace nuclear systems and to provide information required for the design of more economical systems without compromising safety.

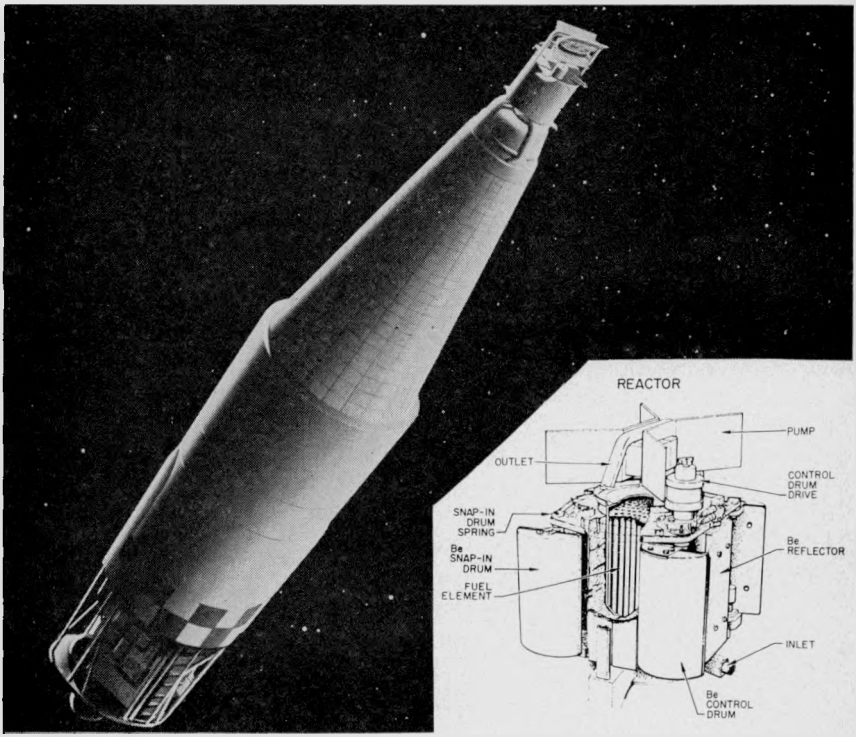
Terrestrial program.—The terrestrial program extends and expands the laboratory and small-scale safety tests initiated under the "reactor safety research and development program", described above, into field prototype and full-scale safety tests under conditions simulating those of actual service operation. The conduct of an intentional test series terminating in an accident of maximum realistic severity in a prototype or full-scale reactor at the NRTS will provide a firmer basis for power reactor design and safety assessment. Such tests will either verify or demonstrate errors in the calculations made on the basis of laboratory and small-scale safety tests. In December, 1961, responsibility for the conduct of the required prototype and full-scale engineering field tests on land-based reactor systems was assigned to the Phillips Petroleum Co.

Aerospace program. The aerospace program emphasizes the safety aspects of the various nuclear devices in operation, or planned for operation, in space environments.

The safety of aerospace nuclear systems must be considered under all operational phases. These include prelaunch conditions (*e.g.*, transportation to the launch site); launch-pad conditions (*e.g.*, launch-pad abort); preorbital conditions, in which the nuclear system could be returned to earth in a potentially hazardous critical configuration if not injected into orbit; and postorbital conditions in which radioactive material might be returned to earth in concentration or form potentially hazardous to human life.

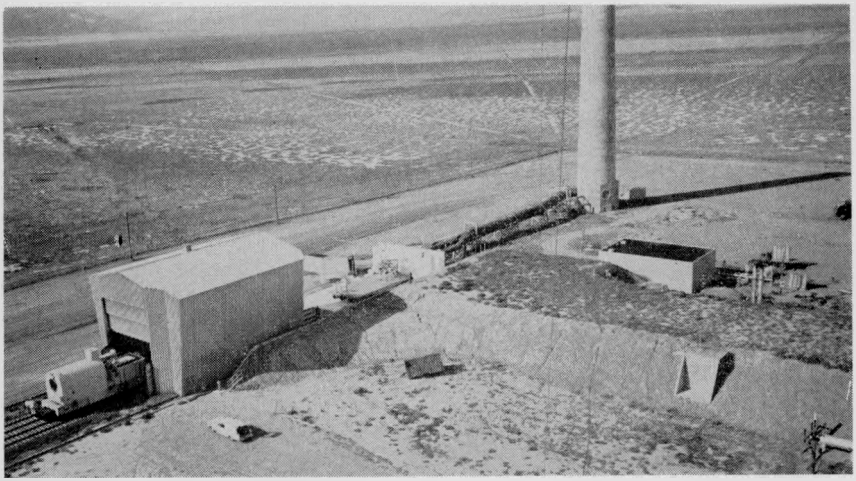
Every aerospace nuclear system must incorporate safeguards against all these potential hazards. One major function of the aerospace nuclear safety program is to conduct field tests to evaluate these safety features. An additional function is to conduct an applied research and development program aimed at broad aerospace safety problems such as nuclear system disintegration and burnup on reentry and the dispersion of radioactive debris in the upper atmosphere. In March 1962, Sandia Corp. was assigned as the AEC prime contractor for this program.

Aerospace safety tests. As an example of the types of activities carried on under the aerospace safety program, several SNAP devices and their individual components have been subjected to launch abort conditions such as violent ground impact and heating from propellant fires. Valuable data have been obtained from these tests making it possible to more readily identify and design for the true nature of the hazards which actually exist. In addition, several experimental devices have been launched "piggy-back" on ATLAS missiles, ejected

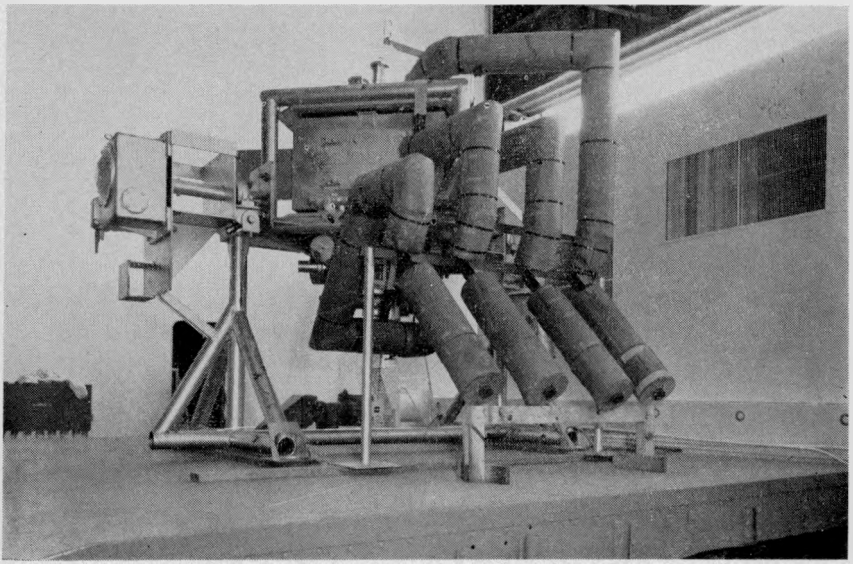


First Reactor Into Space. Producing 500 watts of auxiliary electric power for equipment and instrumentation in space vehicles and satellites, the SNAP–10A is expected to be launched during 1964. When a safe orbit has been achieved, the nuclear reactor will be started by a radio command from earth to provide power for an Air Force satellite. It will be the first reactor-type SNAP (Systems for Nuclear Auxiliary Power) unit to be used in space. The drawing shows how the unit (*upper right*) will appear in space atop the nose cone of the satellite. It is designed to operate for one year in space and was developed for the Commission by Atomics International. Including shielding, the unit weighs 750 pounds. The reactor will have a 30 thermal kilowatt output which will be drawn off by a sodium-potassium liquid metal coolant which, in turn, will pass over thermoelectric elements where the heat will be converted directly into electricity to power the satellite's instrumentation and radio transmitters. *Insert* shows the main components of the reactor.

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Safety Test Facility. The Initial Engineering Test Facility (IETF) at the Commission's National Reactor Testing Station, Idaho, will be the site of extensive testing of SNAP–10A during 1963 as a part of the AEC's aerospace safety program. The tests will ultimately result in the destruction of the reactor. Results of the tests will determine whether the 500-watt nuclear reactor, developed for the Commission by Atomics International, can be sent into a one-year orbital path around the earth by 1964. The reactor will be emplaced on the special four-track railroad car (*center* of photo) shown parked on the test pad. Between tests, the reactor which is expected to become highly radioactive during the destructive experiments, will be housed in the concrete and steel building. The locomotive (*left*) is heavily shielded to protect the crew during movement of the reactor. Photo *below* shows a full-scale mockup of the SNAP–10A reactor (*left*) test package being used in planning the destructive test program. The paper-covered pipes represent equipment that will be used during the test program.



at specified altitudes, and their burnup times observed by cameras. The acquired data have been used to verify the theoretical mathematical calculations predicting the reentry phenomena.

An inert SNAP reactor test package is scheduled to undergo flight safety testing early in 1963. The basic reactor for which this flight test is being conducted is designed to disassemble upon reentry into the earth's atmosphere, thereby ejecting its fuel elements in such a manner that they may be subjected individually to intense aerodynamic heating. The elements should disintegrate (ablate) as a result of this heating, and the residual particulates, which would be radioactive in the case of an operating reactor, should be dispersed harmlessly in the upper atmosphere where they should remain suspended for an indefinite period. The primary purpose of this flight test will be to determine whether or not the reactor undergoes proper disassembly on reentry in accordance with design expectations. A few dummy fuel elements will be included in the experiment to test ejection. No radioactive material will be involved.

Part Three

Production and Weapons Programs

RAW MATERIALS

Procurement of uranium from domestic sources continued during 1962 at close to last year's level of about 17,000 tons of uranium oxide (U_3O_8). Total procurement in the current year was 28,690 tons U_3O_8, 1,620 tons less than a year ago, primarily due to a decrease in foreign receipts.

On April 1, 1962, the program of guaranteed prices for ore and individually negotiated concentrate prices expired and was superseded by the present 1962–66 procurement program under which the Commission purchases uranium in the form of acceptable concentrates at an established price of $8 per pound U_3O_8. Under the current uranium concentrate procurement program, 22 ore processing mills have contracts with the Commission which extend to December 31, 1966; two other plants will close at an earlier date because of limited supplies of eligible ore.

The Commission announced in June that it was relaxing production limitations on small domestic mining properties having production allocations of less than 20,000 pounds U_3O_8 in ore per year which should alleviate problems faced by some small producers who may have been operating on allocations too small to allow a profitable operation.

In November, the Commission announced a new program for domestic uranium procurement from January 1, 1967, through December 31, 1970. The present U.S. uranium procurement program ends December 31, 1966.

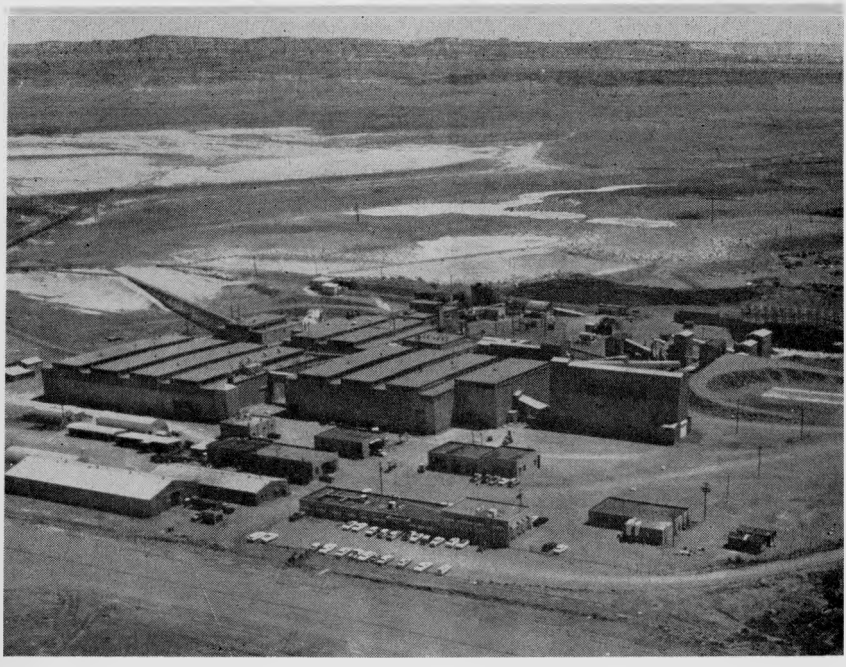
DOMESTIC ACTIVITIES

Uranium Production

Uranium ore production in the United States totaled approximately 7 million dry tons during 1962, as compared to 8 million tons (adjusted figure) in 1961. Receipts of uranium oxide (U_3O_8) in concentrates for the year totaled 28,690 tons of which domestic sources accounted for 59 percent of the total received; Canadian, 26 percent; and overseas receipts, 15 percent.

Uranium Procurement

The Commission's program of guaranteed prices for ore and individually negotiated mill concentrate prices expired March 31, 1962, and was superseded by the present 1962–66 procurement program.



Bluewater Mill. One of the largest of the 24 uranium processing plants under contract to the AEC, the Anaconda Co. Bluewater Mills is located ten miles northwest of Grants, N. Mex. It has a daily milling capacity of 3,000 tons of ore, and separates uranium oxide from a sandstone base rock by means of a leaching process.

Under this program, the Commission purchases uranium in the form of acceptable concentrates at an established price of $8 per pound U_3O_8. The ore-buying program had been in effect since April 1948, and during this period annual domestic uranium production increased from about 100 tons of U_3O_8 to in excess of 17,000 tons; annual ore production expanded from approximately 15,000 tons a year to more than 8 million tons; and known ore reserves increased from about 3 million tons to over 80 million tons. Twenty-four privately owned uranium mills were operating in 1962 as compared with two in 1948.

Stretch-out of 1962–66 Program

The Commission announced on November 17, 1962, a new program for domestic procurement from December 31, 1966, when the present program ends, through December 31, 1970.

The new program consists of a deferral of a portion of the material now contracted for delivery to the Commission before 1967, and the

subsequent purchase by the Commission of an additional quantity equal to the amount deferred. Uranium milling companies have been invited to submit proposals covering the quantity of U_3O_8 in concentrates in their present contracts with the Commission which they would be willing to defer for delivery after 1966. The deferred material would be purchased during the period January 1, 1967, through December 31, 1968, at the prices established for such material under present contracts.

An additional quantity of concentrates, equal to the quantity deferred and delivered in 1967 and 1968, would be purchased during the period January 1, 1969, through December 31, 1970, at fixed prices per pound of U_3O_8. The fixed prices will be determined by applying a formula to allowable costs of production for the period 1963–68, based on an audit of mining and milling costs. The fixed price per pound of U_3O_8 in concentrate will be 85 percent of the allowable production cost per pound plus $1.60, subject to a maximum price of $6.70 per pound.

Small mining properties, those producing less than 20,000 pounds of U_3O_8 annually, will be permitted to participate in the program, up to an overall maximum of one million pounds of U_3O_8 per year, without being required to make a deferral. Concentrates derived from ores produced from such small properties will be purchased in the years 1967–68 at $8 per pound of U_3O_8, and in 1969–70 at $6.70 per pound. This provision is in recognition of the fact that it would not be economical for most small operations to reduce their current rate of production.

The purpose of this program is to effect a better balance between Commission receipts and requirements between now and 1970, and help provide for a continuing industry to supply the anticipated future market.

The official statement concerning the new program was published in the Federal Register on November 20, 1962.

Milling Operations

At the end of the year, there were 24 operating uranium plants, 22 of which were covered by contracts extending to December 31, 1966; two will terminate earlier because of limited supplies of eligible ore. The mills at Lakeview, Oreg., and Gunnison, Colo., were closed during 1961 and 1962, respectively, due to the inability of the mining interests involved to develop an adequate ore supply. The new Petrotomics Co. mill in Carbon County, Wyo., fed its first ore to process in April 1962.

During 1962, the Commission modified and extended contracts with the Vitro Chemical Co. (Vitro Corp. of America) and Mines Development, Inc., providing for the purchase of appropriate quantities of U_3O_8 in the 1962–66 period to be produced from reserves developed prior to November 24, 1958. Also, a new procurement contract was signed between the Commission and the El Paso Natural Gas Co. (originally operated by the Rare Metals Corp. of America) providing for the continuation of this company's milling operations which are based on the eligible ore available from the Western Equities, Inc., Orphan Lode Mine located in Grand Canyon National Park. A bill was passed in May by Congress (Public Law 87–457) permitting mining of that portion of the Orphan Lode ore body on National Park Service ground. This legislation resolved a dispute between the mining company and the National Park Service as to the mining rights to the ore body which extended underground beneath the National Park land. A portion of the eligible ore developed by the company prior to November 24, 1958, was involved in the dispute relating to rights under the mining law.

A list of uranium processing mills as of December 31, 1962, is given in Table 1.

Uraniferous Lignites in the Dakotas

No acceptable proposal has been received for a concentrate contract involving the construction of a mill to process uraniferous lignites in North and South Dakota. At the end of 1961, International Resources Corp. had advised the Commission that it was not in a position to execute a contract, the terms of which had been agreed upon the year before.

The recovery of uranium from lignites involves processing problems not encountered in milling other types of domestic ores. However, a substantial percentage of the uraniferous lignite ores of the Dakotas is committed to companies which have been investigating the feasibility of upgrading the lignite near the mine by burning and then shipping the ash, or possibly an up-graded chemical product, to an existing mill. Five mining companies have commenced mining operations and several others are expected to begin shortly.

Susquehanna-Western, Inc., has announced its intention to provide a market for the ore in the Dakotas eligible for production under the Commission's program, and has established an ore-buying station at Buffalo, S. Dak. Another ore-buying station is proposed at Belfield, N. Dak.

Kerr-McGee Oil Industries, Inc., has obtained options and leases on several properties in the district and is carrying out a program of test mining prior to formulating an operating plan.

TABLE NO. 1.—URANIUM PROCESSING PLANTS

Company	Location of Mill	First Contract Signed	First U_3O_8 Delivered to AEC	Contract Quantity Tons U_3O_8 Deliverable 4/1/62–12/31/66
1. American Metal Climax, Inc	Grand Junction, Colo	7-10-50	June 1951	1,410
2. Anaconda Co	Grants, N. Mex	12-27-51	Sept. 1953	5,354
3. Atlas Corp.[a]	Moab, Utah	6-1-55	Nov. 1956	7,625
4. Cotter Corp	Canon City, Colo	5-23-57	Aug. 1958	752
5. Dawn Mining Co	Ford, Wash	8- 8-56	Sept. 1957	1,305
6. El Paso Natural Gas Co.[b]	Tuba City, Ariz	7-15-55	July 1956	1,034
7. Fed.-Radorock-Gas Hills Partners	Fremont County, Wyo	4-10-59	Dec. 1959	1,850
8. Globe Mining Co	Natrona County, Wyo	5-12-59	Feb. 1960	1,546
9. Homestake-Sapin Partners	Grants, N. Mex	4-23-57	Sept. 1958	7,495
10. Kermac Nuclear Fuels Corp	Grants, N. Mex	5- 3-57	Dec. 1958	11,350
11. Kerr-McGee Oil Industries	Shiprock, N. Mex	8-17-53	Jan. 1955	855
12. Mines Development, Inc	Edgemont, S. Dak	4-28-55	Aug. 1956	1,581
13. Petrotomics Co	Carbon County, Wyo	8-12-60	Apr. 1962	1,579
14. Phillips Petroleum Co	Grants, N. Mex	9-17-57	Aug. 1958	6,673
15. Susquehanna-Western, Inc	Riverton, Wyo	12- 4-57	Jan. 1959	1,948
16. Susquehanna-Western, Inc	Falls City, Tex	7-25-60	June 1961	624
17. Texas-Zinc Minerals Corp	Mexican Hat, Utah	7-17-56	Nov. 1957	4,204
18. Union Carbide Corp.[c]	Maybell, Colo	8-10-55	Dec. 1957	927
19. Union Carbide Nuclear Co	Rifle, Colo	10- 2-47	Dec. 1947	[d] 5,625
20. Union Carbide Nuclear Co	Uravan, Colo	4-13-49	Mar. 1950	
21. Utah Construction & Mining Co	Fremont County, Wyo	11-14-56	Mar. 1958	4,562
22. Vanadium Corp. of America	Durango, Colo	2-17-49	Aug. 1949	1,781
Ore Upgrader	Naturita, Colo			
23. Vitro Chemical Co	Salt Lake City, Utah	10-25-51	Oct. 1951	805
24. Western Nuclear, Inc	Jeffrey City, Wyo	8-10-56	Aug. 1957	4,525
Ore Upgrader	Converse County, Wyo			

[a] Formerly Uranium Reduction Co.
[b] Formerly Rare Metals Corp. of America.
[c] Formerly Trace Elements Co.
[d] Total for both mills.

NOTES.—The above mills are privately owned and operated, and all are licensed to buy and process uranium ores from producers. The U.S. Atomic Energy Commission buys the concentrate product under the terms of contracts with each mill operator.

All contracts extend through December 31, 1966, except that with Cotter Corp. which expires Feb. 28, 1965, and that with Vitro Chemical Co. which expires Dec. 31, 1963.

In most cases any quantities of U_3O_8 in concentrate derived from eligible independent ore processed in the mill are in addition to the above quantities.

If the lignites or an up-graded product can be economically produced and delivered to an existing mill, the milling contract would be modified to permit acceptance of the material and sale to the Commission of the U_3O_8 in concentrates produced. The quantity of uranium in concentrates which the AEC purchases will be established within the framework of the Commission's uranium procurement program.

Production from Small Mines

It was announced on June 29, that the Commission was relaxing production limitations on small domestic mining properties having

production allocations of less than 20,000 pounds of U_3O_8 in ore per year. Accordingly, the mills delivering uranium concentrates to the Commission were authorized to accept deliveries of ore from such small mining operations, irrespective of the allocations assigned to them. Up to 10,000 pounds of contained U_3O_8 can be accepted in each 6-month period beginning January 1 and July 1 before January 1967. For the 9-month period, April 1, 1962, to December 31, 1962, any such mining property unit could deliver up to 15,000 pounds of U_3O_8.

The decision to relax the limitation on production was the result of a Commission review on the effect of allocation procedures on small mining operations. This action should reduce the problems faced by the small mine operators who have played an important role in developing the domestic uranium industry and will permit continued mining and development of their eligible properties.

Ore Reserves

During 1962, the Commission's estimate of domestic uranium ore reserves was revised downward following a detailed study of data available from extensive underground development and open-pit operations. This detailed study covered 110 uranium deposits and mines accounting for approximately 90 percent of the total estimated reserves. Much of the original ore reserve information had to be based on the results of exploration drilling, and in some cases the interpretation of the drilling data failed to indicate with sufficient accuracy the irregularities of the deposits and the average grade. The revised estimate of January 1, 1962, gave reserves totaling 71 million tons of ore containing 175,000 tons of U_3O_8. This is 3 million tons less than the tentative 74 million ton ore reserve figure previously published. However, the revised estimate of the U_3O_8 content of the ore reserves reflected a greater adjustment, being 36,000 tons of U_3O_8 less than the earlier figure. Until such time as another comprehensive review of ore reserves is indicated, the above estimate will be adjusted annually to reflect ore mined and newly developed reserves. Domestic ore reserves in place at the end of 1962 are estimated at 68 million tons of ore containing 167,000 tons of U_3O_8. This is a reduction of 3 million tons as compared with the estimate for the previous year. Although ore mined in 1962 amounted to 7 million tons, this was partially offset by the addition of 4 million tons of ore in newly developed reserves. Exploration has practically ceased except for more accurate delineation of known ore bodies. The quantity of ore milled exceeded the quantity mined by about 500,000 tons resulting in a corresponding decrease in ore in stockpiles. Stockpiles at the year end totaled 800,000 tons of ore containing approximately 3,400 tons of U_3O_8.



Heap Leaching Project. This open-air method of recovering uranium is operated by Lucky Mc Uranium Division, Utah Mining and Construction Co., in the Gas Hills area of Wyoming. Low grade material from a strip mining pit (0.05 to 0.07 percent U_3O_8 and not suitable for mill processing) is trucked in and placed on a polyethylene pad with ponds arranged as shown. This pile is about 20 feet deep and approximately 500 by 600 feet. Barren raffinate from the Lucky Mc mill flows by gravity to the first pond, and then seeps over to the other ponds. The acid in the raffinate leaches the uranium out of the material as it seeps downward to the polyethylene pad where the pregnant liquor is collected by a system of pipes and pumped back to the mill for processing. Lucky Mc has been operating this heap leaching project successfully for nearly 4 years.

Radioactive Hazards in Uranium Mills and Mines

Uranium ore processing mills are Commissioned-licensed operations subject to Commission regulatory control, including Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation." The physical control of concentrations of uranium ore dust and of uranium concentrate dust in the mill atmosphere, and also of concentrations of radioactive constituents in liquid effluents from the mills, requires continual surveillance in order to comply with established standards. The application of these regulations to activities in uranium mills has increased the safety of mill workers from radiation and substantially improved working conditions.

Radiation hazards also exist in uranium mines, principally due to the release of radon gas from the uranium minerals. When ventila-

tion rates are too low, the concentration of radon and its radioactive decay products rises to levels which would present a potential hazard if they were long continued. The radioactive hazards of uranium mines are subject to control under the provisions of State regulations and the Commission assists the State and other Federal agencies concerned with this problem in conducting environmental surveys and developing procedures to control the mine air contamination level. Control of the air contamination hazard is included in the health and safety features of the mining regulations of the State agencies concerned. During the past year the mining companies, in cooperation with the State agencies, were reported to have made ventilation and other improvements which had the effect of substantially reducing excessive concentrations of these products in the mine air. Continued surveillance is being maintained in most of the mining areas. Cooperative studies by the U.S. Bureau of Mines in AEC leased mines resulted in the development of a procedure for estimating full shift levels of exposure of mines which was published by the Bureau.

FOREIGN ACTIVITIES

Concentrate Deliveries

Deliveries of foreign uranium concentrates to the United States during 1962 totaled 11,680 tons of contained U_3O_8 with 7,410 tons coming from Canada, 4,085 tons from South Africa, and 185 tons from the Combined Development Agency (CDA) contracts with Australia and Portugal.

Canada

Canadian receipts were again reduced during the current year as a result of the stretch-out agreement between the Commission and Canada.[1] Delivery of a total of about 315 tons of U_3O_8 previously scheduled for delivery in the Fiscal Years 1962 and 1963 is being deferred to later years.

Of major interest to uranium producers throughout the world was the announcement in July that the United Kingdom Atomic Energy Authority (UKAEA) would purchase an additional 24 million pounds of U_3O_8 from Canada at a cost of $127.7 million (Canadian currency). Deliveries will begin upon completion of existing contracts and will not be finally completed until 1970. The announcement stated that the average price to the Canadian producers will be $5.03 (Canadian currency).

[1] See pp. 61 and 62, Annual Report to Congress for 1959.

The agreement which was reached after extended discussions represented a negotiated settlement of an arrangement covered by a 1957 exchange of letters between the UKAEA and Canada (Eldorado Mining and Refining, Limited). These letters referred to exercise of options contained in purchase contracts. The U.S. Atomic Energy Commission also held options to purchase additional Canadian uranium in the post-1962 period. However, as a result of the increase in domestic production capability, these options were not exercised.[2]

Overseas

Final deliveries to CDA were completed during 1962 from Radium Hill in South Australia fulfilling the terms of the contract which expired December 31, 1961. Deliveries from Portugal were completed in April 1962. The last of the contracts involving joint United States-United Kingdom procurement through the CDA, the contract for the production from the Rum Jungle mine and mill in northern Australia, terminates in early January 1963.

South Africa deliveries were as projected. Procurement from South Africa will continue through December 1966.

Assistance to Foreign Geologists and Engineers

Twenty foreign geologists and engineers from eight countries (Argentina, Belgium, France, India, Japan, Mexico, Turkey, and Yugoslavia) completed programs of training or familiarization in uranium geology, exploration, mining, and processing during 1962.

The visitors to the United States, all members of, or associated with, the atomic energy organizations of their respective countries, were, with one exception, sponsored by either the International Atomic Energy Agency (IAEA) under their Fellowship Program or by the Agency for International Development (AID). The programs included visits to principal uranium districts and mills for observation and familiarization of the various types of uranium ore deposits, mining methods and equipment, and uranium processing techniques. Arrangements for visits to the uranium mills have been made between the National Research Council and the mill being visited.

At the request of the Argentine, Mexican, and Yugoslav Governments, three Commission geologists were sent to those countries in 1962 to review their uranium exploration programs. The IAEA sponsored the Argentine and Mexican visits, and AID sponsored the Yugoslavian trip.

[2] See pp. 61 and 62, Annual Report to Congress for 1959.

PRODUCTION

Source and special nuclear materials as well as other production materials such as tritium and heavy water continue to be produced or processed in calendar year 1962 in quantities in compliance with Presidential Directives or as required to satisfy military and peaceful needs.

Operations

Reductions in unit operating cost were achieved in many areas of the production complex. One cost reduction measure was initiated on July 1, 1962, when all refining operations were consolidated at Weldon Spring, Mo., while the Fernald, Ohio, refinery was placed in standby. The uranium hexafluoride (UF_6) feed production plant at Portsmouth, Ohio, was also shut down early in 1962 and placed in standby. Since the Oak Ridge, Tenn., plant had previously been shut down late in 1961, processing of feed to UF_6 for the gaseous diffusion cascades continues only in the AEC plant at Paducah, Ky., and the privately owned Allied Chemicals Plant at Metropolis, Ill.

UF_6 Shipments

The Oak Ridge and Portsmouth gaseous diffusion plants shipped a total of 196,000 pounds of enriched uranium hexafluoride during 1962 to private industry. This material was valued at $29,000,000. Most of the uranium hexafluoride shipped will be used to fuel power reactors, both in the United States and in foreign countries. Shipments were made during the year for the SELNI and SEAN power reactors in Italy, and for a power demonstration reactor in Germany. Other shipments were made to the French, Norwegian, and Japanese governments.

Criticality Incident

The Commission's Plutonium Scrap Recovery plant at Hanford, Wash., was shut down when a criticality incident occurred on April 7. Subsequently, a decision was made not to assume operations in the facility since a new plant, now under construction, will be in operation by the end of 1963.

Three men received estimated whole-body neutron and gamma doses ranging from about 19 to 110 rems during the criticality incident which occurred in a transfer tank during a cleaning and maintenance

operation. They were placed in the hospital for medical observation and testing immediately following the incident, but returned to work in 9 days and still show no clinical radiation effects.

Paducah Fire

On December 13, a chemical explosion started a fire in one of the four large Gaseous Diffusion Plant buildings at Paducah, Ky. The fire, fed by oil which lubricates equipment, was brought under control by the immediate action of automatic sprinkler systems with supplementary firefighting activities by the plant and the City of Paducah Fire Departments.

There were no injuries to personnel, and there was no radiation hazard.

A large quantity of siding was removed from the building by the explosion, and the preliminary estimate of the total damage done to the equipment and the building is $2 million. The fire protection equipment which had been installed in 1959 is credited with preventing the possible destruction of the entire 22-acre building whose cost with equipment, amounted to $162 million. By December 17, a sufficient number of diffusion process cells in the plant were returned to operation to utilize 90 percent of the electrical power normally used in the Paducah facility.

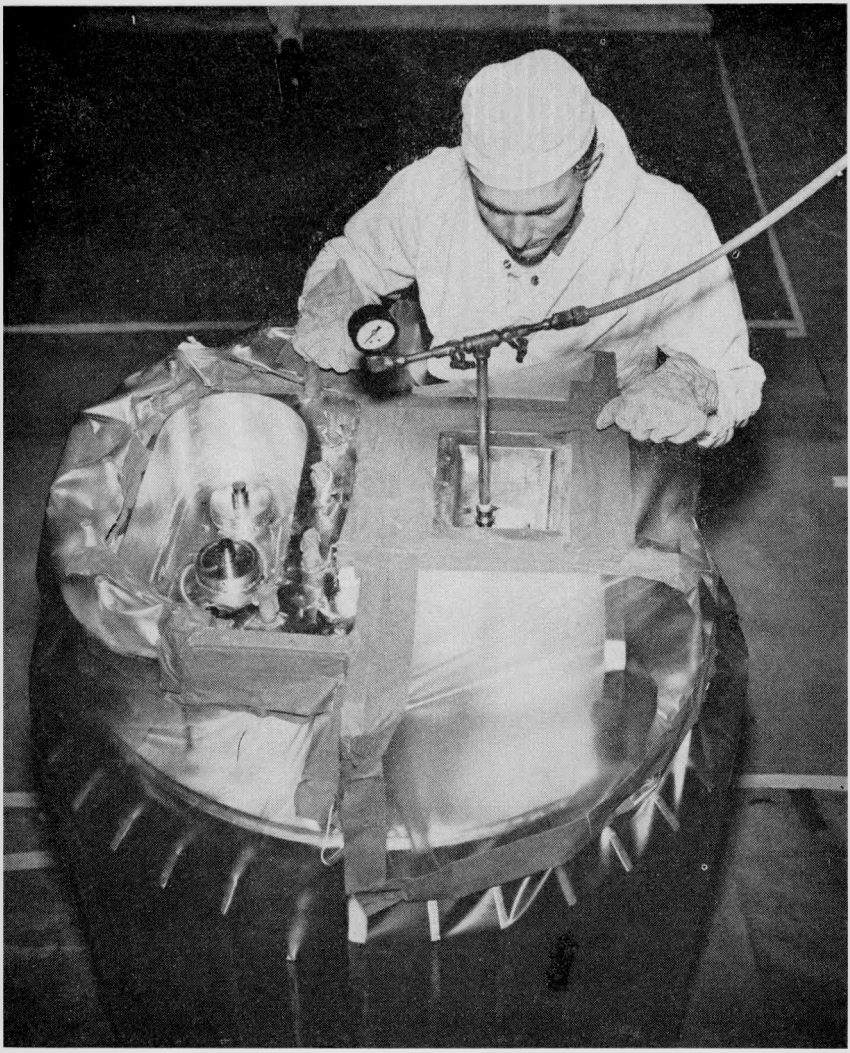
The section of the plant where the explosion occurred had been under maintenance conditions and was being brought back into operation at the time of the explosion. An investigative committee was appointed to determine the cause of the explosion and to make recommendations for preventing similar incidents in the future.

Fission Products Production Program

The Commission's Hanford plant continued to recover strontium 90 and cesium 137 from the Purex chemical processing plant waste stream (raffinate and furnish these fission products to other Commission programs (SNAP and Isotopes Development).

During calendar year 1962, approximately 2,200 kilocuries of strontium 90 were recovered as a crude concentrate from the Purex plant head-end process and sent to the Hot Semiworks Facility for purification. During the year, the Hot Semiworks at Hanford produced 2,222 kilocuries of purified strontium and shipped 525 kilocuries of this production to Oak Ridge National Laboratory, Tenn., and 569 kilocuries to the Martin-Marietta Co. facility at Quehanna, Pa., for fabrication into isotopic heat sources and other applications. The first shipment to Quehanna was made in July 1962. The balance

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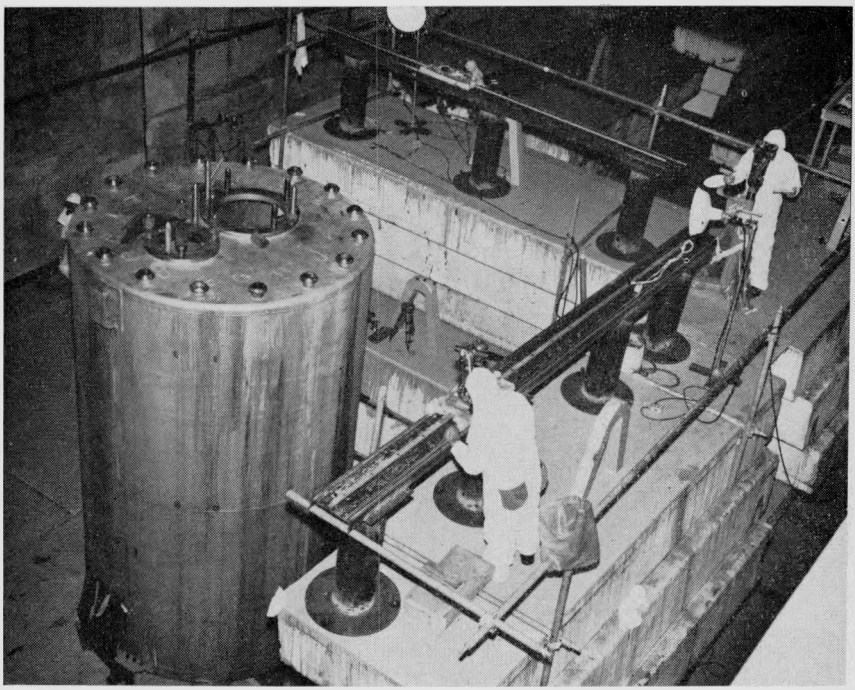


Shipping Cask. Strontium 90 is currently being used in the Commission's SNAP programs in ever increasing amounts. The strontium provides the heat energy from radioactive decay, which, through thermoelectric generators, is used to power the SNAP units. This photo, taken at the Hanford installation, shows a pressure measurement being taken of the strontium 90 in a HAPO II cask prior to shipment to Oak Ridge, Tenn., for final processing. The shipping system, which includes a filter-container for the product within the cask, was designed by General Electric Co., prime contractor at the Commission's Hanford installation. The shipping cask shown here fits into a buffered container. The plastic cover keeps dust from settling on the cask while it is being prepared for shipment.

of the Hot Semiworks 1962 production is awaiting shipment to Oak Ridge and Quehanna.

In addition to the strontium 90 production, 552 kilocuries of cesium 137 were recovered from the supernatants of the aged wastes in Hanford's waste tanks and shipped to Oak Ridge for Isotopes Development program needs.

Storage facility. Modifications were completed in a portion of Hanford's "B Canyon"—one of the three inactive separations plants built during wartime for plutonium recovery—to handle and store two crude fission product fractions, strontium 90 and promethium 147/rare earths for decay of objectionable short-lived isotopes of strontium and promethium. Storage capacity is 10,000 kilocuries for each of the two fractions. This stored material can be sent to the



Fission Product Storage. In the photo, General Electric Co. employees are shown taking as-built measurements of one of the storage tanks to be installed in the Hanford "B Canyon." This and other storage tanks in the modified canyon building will be used to store crude fission products before processing to retrieve strontium 90 and other radioisotopes. The tank was placed in one of the seven cells (below the canyon deck) which were readied during 1962 for the handling and storage of millions of curies of the crude fission product fractions.

Hot Semiworks as necessary for processing into purified products. In order to provide for sudden demands for strontium 90 or unforeseen shutdowns of the Hot Semiworks, storage capacity for 2,000 kilocuries of purified strontium 90 products was installed adjacent to the Hot Semiworks.

Commercial Cold Uranium Scrap Processing

Responsibility for implementation of the Commission's enriched-uranium "cold" (nonradioactive) scrap recovery program in commercial facilities was assigned to the Commission's Division of Production, effective July 1, 1962. Concurrent with the transfer, the field implementation of this program, which was formerly assigned to the New York Operations Office, was assigned to the Oak Ridge Operations Office.

During 1962, following invitations to bid, 22 contracts were awarded to 4 private industrial firms for the recovery of 64 lots of cold uranium scrap. The awards, with a total value of $764,182, were made to the Davison Chemical Division of W. R. Grace and Co., Erwin, Tenn.; Nuclear Materials and Equipment Corp., Apollo, Pa.; United Nuclear Corp., Hematite, Mo.; and National Lead Co., Albany, N.Y.

Gas Centrifuge Studies

The expanded development program for gas centrifuge studies which the Commission approved in 1960 was continued during 1962 at a level of about $2.3 million. The four contractors engaged for the work include the University of Virginia, the Union Carbide Nuclear Corp., AiResearch Manufacturing Division of the Garret Corp., and Yale University. The Oak Ridge Operations Office administers the work of all four contractors.

The development program includes work on materials, dynamics, flow theory, mechanical testing, and separation experiments of heavy isotopes as a means of enriching uranium. The development program is being conducted on a classified basis.

Since the Commission, in April 1961, amended its regulations to extend its access permit program to classified areas of this field, five permits have been issued to U.S. industrial firms—the Dow Chemical Co., Allied Chemical Co., General Electric Co., United Nuclear Corp., and the Bendix Corp.

Processing Facilities

Fuel Processing Plant Proposal

Nuclear Fuel Services, Inc. (NFS), a new corporation jointly formed by W. R. Grace and Co. and the American Machine and Foundry Co., submitted a preliminary proposal to the AEC in June 1962 to provide commercial irradiated nuclear reactor fuel processing services. Its proposed commercial fuel processing plant would have nominal capacity of approximately 1 ton per day of normal or slightly enriched uranium; the plant would also have capability for handling fuels of higher uranium enrichments but at reduced capacity.

In July 1962, NFS filed with the Commission a detailed license application for construction and operation of the proposed processing plant. The application contemplates beginning of construction in the spring of 1963. The site selected by NFS for the plant is at the State-owned Western New York Nuclear Service Center, approximately 30 miles south of Buffalo, N.Y. Both the Advisory Committee on Reactor Safeguards and the AEC Licensing and Regulation staff have stated that the selected site could be considered suitable for a plant of the type and capacity proposed by NFS. The NFS application, as amended, for plant construction and operation is currently being evaluated within the AEC relative to issuance of a construction permit.

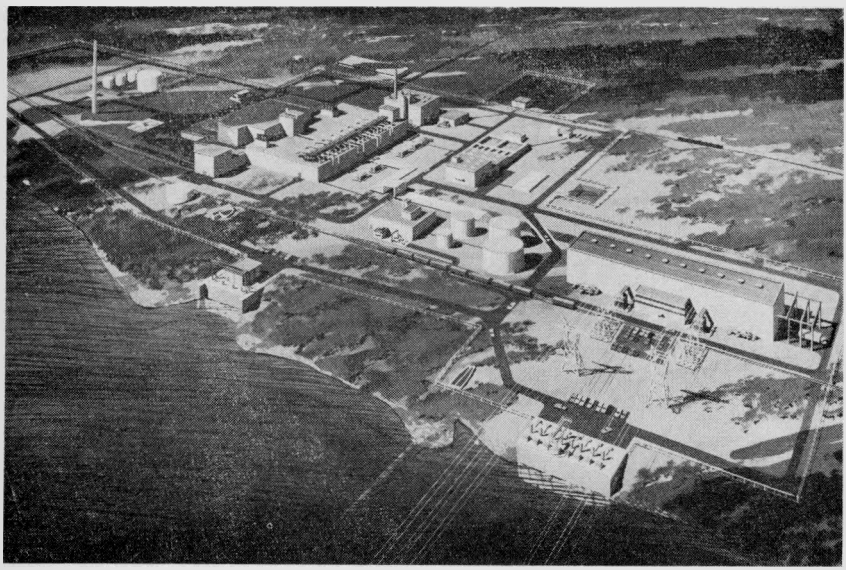
Contractual arrangements. The AEC is presently exploring with NFS, the contractual arrangements under which a portion of Commission fuels would be processed in the NFS plant as a base load for the plant. In addition to negotiations with the Commission, NFS is negotiating contracts with a number of utility companies which are, or will be, operating nuclear power plants. The AEC announced, in 1957, that it would accept irradiated fuels from licensees through June 30, 1967, but would withdraw from providing such services if they became available commercially at reasonable charges. The determination as to whether proposed NFS charges are reasonable is expected to be made upon the review of NFS charges and the essential terms and conditions of contracts covering services to be provided.

The AEC has offered to private reactor operators, as an alternative to delivering their spent fuels to AEC at Commission-owned facilities the option of the AEC accepting the fuels at the reactor site and the reactor operators providing the storage capability for an agreed upon period. Negotiation of the storage contracts with some reactor operators are under way.

New Production Reactor

Construction

The current official cost estimate for the New Production Reactor (NPR) under construction at Hanford, Wash., and the associated supporting facilities (exclusive of the proposed power plant) is $195 million. The scheduled completion date is October 1963. However, this cost estimate and scheduled completion are currently under review to assess the impact of difficulties experienced during the past year in the design and procurement of engineered equipment and fabrication and installation of high quality, heavy wall, welded carbon steel pipe. As of November 30, 1962, design of the reactor was 100 percent complete and construction was 69.5 percent complete.



World's Largest. Artist's conception of how the New Production Reactor (NPR) power facility at Hanford, Wash., will look when completed. Steam generated in the NPR (*left* portion of drawing) will be piped into the 800,000 electrical kilowatt generating station (*right*), making it the world's largest nuclear power producing facility. The generating facility would be built and operated, at no cost to the Government, by the Washington Public Power Supply System.

Sale of Byproduct Steam

The New Production Reactor (NPR) is designed primarily for plutonium production, but includes features which will permit the addition of electric power generating facilities. In accordance with

the provisions of Congressional action (PL 87–701), the possibility of building a 800,000 electrical kilowatt generating facility to use NPR steam is being carefully explored. The Washington Public Power Supply System (WPPSS), composed of a group of public utility organizations in the State of Washington, has made a proposal to build and operate a power plant to generate approximately 800,000 kilowatts of electric power through the use of excess steam from the NPR. The electricity generated would be distributed on a 50/50 basis to private and public (or cooperative) utilities. The Federal Government would not bear any of the costs arising from the power generation, but would receive payments for making available the excess steam. The contemplated arrangements are being made in accordance with Congressional action (PL 87–701) in 1962.

RADIOACTIVE WASTE MANAGEMENT

Of prime importance in all nuclear operations is the management of those waste byproducts which may be radioactive in themselves or contaminated with radioactivity. Since radioactivity cannot be neutralized except by the passage of time to allow for natural decay, waste disposal operations must be conducted in a manner that will offer adequate protection for the public health and safety during the period of potential hazard—which may range from a few days to many, many years. Thus, the AEC maintains a strict control on actual disposal operations conducted by its own facilities and contractors as well as by firms licensed for radioactive waste activities. In addition, the Commission fosters a continuing program of research and development for the management of radioactive wastes.

Land Burial of Radioactive Wastes

To assure adequate protection of public health and safety during the period of any potential hazard, it is Commission policy to license for land-burial of radioactive wastes only on Government-owned land (Federal or State). In September 1962, the AEC issued the first license for land burial of low-level radioactive wastes to the Nuclear Engineering Co. of Pleasanton, Calif., for burying such waste on State-owned land near Beatty, Nev.

Under the Commission program of transferring licensing responsibilities to State governments, it is possible for a State having such an agreement with the AEC to establish and control low-level radioactive waste burial grounds for the benefit and convenience of its citizens. In October 1962, the State of Kentucky issued a license to the

Nuclear Engineering Co. for the operation of a low-level radioactive waste burial ground near Flemingsburg. Currently, the State of New York is considering the establishment of a radioactive waste burial ground at its Western New York Nuclear Service Center, 30 miles south of Buffalo.

Interim program. Since May 1960, the Commission has made the burial grounds at the Oak Ridge National Laboratory, Tenn., and the National Reactor Testing Station, Idaho, available for use by licensees in disposing of suitable packaged low-level solid wastes, at a burial charge of 70 cents per cubic foot with a $21 minimum, during the interim period until suitable permanent land burial facilities were available to the licensees. For Fiscal Year 1962, these two burial grounds reported a total of 69,000 cubic feet of wastes buried for licensees under this Interim Burial Program and 22,000 cubic feet of wastes buried for other Government agencies. This is about equal to the amounts of this type of material that was buried at these locations in FY 1961.

On-site burial. The AEC burial grounds, located at Savannah River, S.C.; Idaho; Hanford, Wash.; Oak Ridge; Los Alamos and Sandia, N. Mex.; the Nevada Test Site; Project Gnome, N. Mex.; Weldon Spring, Mo.; Fernald and Portsmouth, Ohio; and Paducah, Ky., reported a grand total of 2,359,000 cubic feet of solid radioactive wastes buried during FY 1962; this is about two-thirds of the total amount that was buried in FY 1961. These buried wastes, which were mainly generated by the Commission and its contractors, ranged from low to high radioactivity.

High-level Waste Management

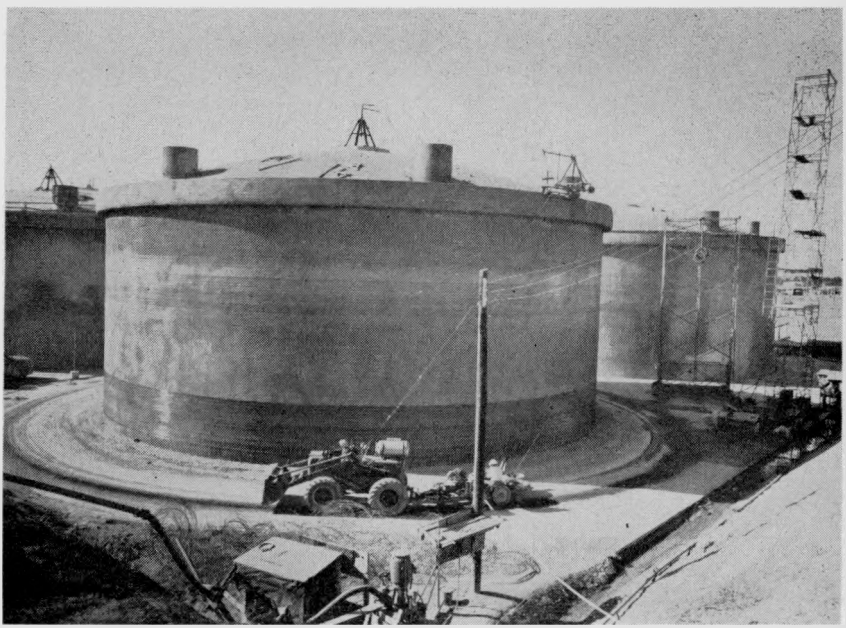
Table No. 2 summarizes some pertinent information concerning the management, storage, and surveillance of the high-level radioactive liquid wastes resulting from the Commission's chemical processing operations at the Savannah River, Hanford, and Idaho facilities. As these operations continue, managing and surveillance of the accumulating liquid wastes—most of which have high levels of radioactivity—will be increasingly important in the AEC production complex and planning. During the past year the radioactive waste program of the Commission's Division of Production has placed additional attention on the radioactive waste problems inherent in the chemical processing operations for recovering usable source and special nuclear material from spent reactor fuels. An important aspect is

that the many variables involved in the chemical processing operation itself can effect the waste management program.

Tank storage. Experience to date with storage of liquid radioactive wastes in large underground tanks is insufficient to make accurate predictions on tank life. While estimates of useful life range from 20 to

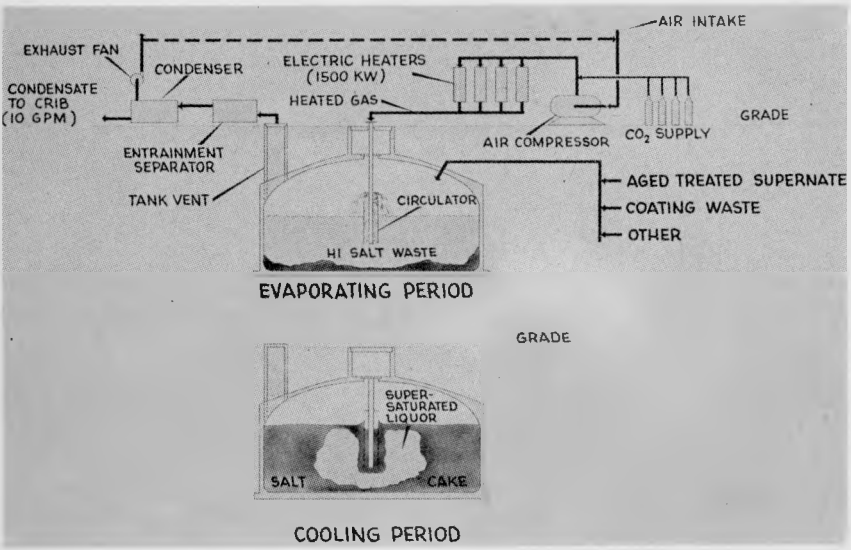
TABLE NO. 2.—STORAGE OF HIGH-ACTIVITY LIQUID WASTES

	Savannah River	Hanford	Idaho
1. Total capital expenditures for liquid waste management, storage, and surveillance facilities	$28,000,000	$69,000,000	$11,000,000
2. Liquid waste storage tanks at site	12— 750,000 gal. 4—1,000,000 gal. 8—1,300,000 gal.	21—1,000,000 gal. 48— 758,000 gal. 60— 530,000 gal. 16— 55,000 gal.	0—300,000 gal. 4— 30,000 gal.
3. Tanks under construction or to be constructed during the next 2 years (all for self-boiling waste)	4— 500,000 gal.	4— 580,000 gal.	4—300,000 gal.
4. Magnitude of average annual operating expenditure for waste management and surveillance	$800,000	$900,000	$100,000



New Storage Tanks. Photo shows three new liquid waste tanks under construction at the Commission's Savannah River Plant in South Carolina. Post tensioning wire is being wound around the first layer of concrete which had been placed around the inner, steel tanks. Subsequently, a second layer of concrete was placed around the wire and the tanks were covered with earth. There are 24 tanks now in use at Savannah River for storage of high-level radioactive wastes.

greater than 50 years, undoubtedly, and this has been the experience, a few tanks will fail earlier. The Commission's waste tank farms are under continuous management and surveillance and while there now have been a total of nine tanks (four at Savannah River and five at Hanford) either withdrawn from further service or given limited use because of leaks or suspicion of leaks, there has never been any significant contamination of the earth surrounding the tanks.



In-Tank Solidification. Drawing shows one method under consideration by the AEC for solidification of high-activity liquid wastes within storage tanks. Such solidification would provide positive assurance of containment of the wastes and a possible means of ultimate disposal of high-level wastes with a minimum of surveillance necessary. The idea is being developed for the Commission by the General Electric Co., contractor-operators of the Hanford, Wash., Plant.

Long-range studies. In order to continue storing liquid wastes in tanks at the Commission's chemical processing sites, it will be necessary to construct additional storage tanks for new waste and also to replace tanks which become unsuitable for further use. Faced with this prospect, the Commission's chemical processing contractors are incorporating long range planning into their waste management programs. They are examining ways to obtain the maximum possible use of the storage tanks now available, (*e.g.* in-tank solidification) and are considering processing some of the long-lived radioisotopes to a solid form providing more positive assurance of containment and possibly a means of ultimate disposal to minimize the efforts of perpetual surveillance of radioactive wastes.

Reducing Radioactive Isotopes in Columbia River

The Columbia River radiological surveillance program continues to show that in 1962: (*a*) the exposures received by the vast majority of the people in the vicinity of the Hanford Plant were from natural sources or worldwide fallout, (*b*) the radionuclides of Hanford origin found in the river were within established limits, and (*c*) the phosphorus 32 found in locally-caught white fish can be a significant though not hazardous source of exposure to the few persons who eat them in quantity.

Changes and improvements in the water treating processes used at the Hanford reactors, that were introduced in 1961 to reduce the mineral content of the reactor cooling water—drawn from the Columbia River—were continued through 1962. The quantity of alum used in treating the water had been increased thereby obtaining greater precipitation of the impurities. By this means, the discharge to the river of radioisotopes such as phosphorus 32 and arsenic 76 have been maintained at about half of the pre-1961 levels.

Film layer problem. Investigations are continuing on methods to bring about further reductions. For instance, neutron activation of the impurities in the water passing rapidly through the reactor does not account for the amount of activity found in the effluent. It is necessary to ascribe a "residence time" in the reactor to obtain the observed amount of activation. The only location seen for such a residence is in the film that forms on the surface of the tubes and fuel elements. Hence, efforts are concentrating on methods for modifying or eliminating the film layer.

Basic studies of improved water treatment methods are first carried out on a laboratory scale. Any methods that look promising are then tested in a water treatment pilot plant coupled to selected reactor tubes of an operating reactor. It is expected that this pilot testing will permit the separation of variables so the underlying phenomena can be determined. Treated drinking water drawn from the river by downstream users is well within established standards for permissible radioactivity, however.

Coordinated study. Agencies other than the AEC are conducting investigations on the Columbia River. In some cases, the small concentration of radioactivity in the water provides a unique tool, permitting investigation of natural phenomenon not otherwise practical to investigate. The radioactivity has permitted a much more detailed investigation of the ultimate fate of Columbia River water in the ocean than previous techniques.[3]

[3] See "Fundamental Nuclear Energy Research—1962."

This information, although obtained on the Columbia, is of potential use in defining all fresh to salt water discharge systems. Also, the transport of sediments in the river, behind dams, and in estuaries can be characterized much more easily in this system than otherwise. To coordinate internal as well as external research, a Columbia River Study Group, composed of State, Federal, and university representatives, has been established to insure that duplication is avoided and that areas of interest are not neglected.

PACIFIC OCEAN DISPOSAL STUDY

Concluding a 4-year study, the National Academy of Sciences–National Research Council on September 30 made known its conclusions and findings [4] regarding the disposal of radioactive wastes in the Pacific Ocean. The study was undertaken at the request of the Commission in 1958. The report, prepared by a panel of scientists, said that the low-level waste disposal operations can continue to be carried on "without danger to human or fish populations."

The National Academy of Sciences–National Research Council (NAS–NRC) Committee on Oceanography was asked to study disposal of these low-level wastes into the deep waters of the Pacific Ocean. The report also deals with considerations and recommendations for planning future waste disposal in the Pacific, although the Commission has no present plans to designate any additional sites for disposal of low-level wastes into the ocean.

Disposals Made Since 1946

The AEC permits disposal of packaged low-level radioactive wastes in designated areas of the Atlantic and Pacific Oceans. Such disposal has been performed by authorized AEC licensees or Commission contractors since 1946. The Commission requires that sea disposal of these packaged low-level wastes be made at a minimum depth of 1,000 fathoms (6,000 feet) to assure safe dilution and dispersal of any radioactivity which ultimately may be released.

Typical low-level wastes disposed of at sea are paper wipes, rags, broken glassware and other laboratory paraphernalia which are packaged in concrete to assure that the containers maintain their integrity while descending to 1,000 fathoms in the ocean, the minimum depth required by AEC.

[4] "Disposal of Low-Level Radioactive Wastes into Pacific Coastal Waters" available from National Academy of Sciences, 2101 Constitution Avenue NW., Washington 25, D.C., price $2.

Three Sites

Three designated sites—all with a minimum depth of 1,000 fathoms—off the Pacific Coast have been used in the past. The principal site has been a dumping area on the seaward side of the Farallon Islands, about 48 miles west of San Francisco. Since 1946, approximately 14,800 curies of radioactive material (at the time of preparation for disposal) have been disposed at this site; of this total, approximately 600 curies have been disposed in the last 4 years.

Other sites which have been used in the past are in the Santa Cruz Basin, some 32 miles southwest of Port Hueneme, Calif., where approximately 100 curies of low-level waste (at the time of preparation for disposal) have been disposed, and a site 130 miles southwest of Point Arguello, Calif., in about 2,000 fathoms of water, where approximately 33 curies of low-level waste (at the time of preparation for disposal) have been buried. The Santa Cruz Basin site no longer is used for ocean disposal.

Sites Could Be Increased

Extensive environmental surveys of the Farallon Islands and Santa Cruz Basin sites have been conducted. These surveys, made in 1957 and again in 1960, showed no radioactivity above natural background radiation in the water, sediments, or marine life in the disposal areas.

The panel scientists used a novel technique for determining the permissive rates and amounts of waste disposal in the sea. They derived "specific activity" numbers which are the maximum permissible intake or ingestion rate for a particular radioisotope as recommended by the National Committee on Radiation Protection divided by the amount of the nonradioactive or stable element of the same species in the biological organ under consideration. If this ratio of radioactive to nonradioactive amounts of an element is not exceeded in any food or environment from which the food is derived—in this case, the sea—then no creature in the food chain can absorb more than a permissible amount of radioactivity. With this approach, it is then possible to calculate the portion of each element which can be radioactive without hazard to life. The panel's report cites that their recommendations for ocean disposal are such that even if the radioactive wastes escape from the container, they are safely diluted by the nonradioactive chemical elements in the sea. Under such conditions, no sea life could absorb enough radioactivity as to cause harm to humans, even if they ate nothing but seafood.

Land Burial Cheaper

The National Academy of Sciences panel notes that, if needed, as many as 20 sites for sea disposal of low-level radioactive waste could be safely established from the Mexican Border to the Columbia River, with a similar number north of the Columbia River. As noted above, however, the AEC has no present plans to increase the number of sea disposal sites for packaged waste, since the present number of locations is more than adequate to handle the small amount of low-level wastes being disposed of at sea. Because of economic considerations, however, more than 95 percent of the low-level wastes are now buried on land.

MILITARY APPLICATION

The Commission, through its Division of Military Application, and working in coordination with the Department of Defense, conducts the research, development, testing, and production necessary to provide the Nation with a nuclear defense capability.

WEAPONS DEVELOPMENT AND PRODUCTION

Weapons Development

During 1962, development of weapons designed to meet stated military requirements was continued at the Commission's three weapons laboratories—Sandia Corp., Los Alamos Scientific Laboratory, and Lawrence Radiation Laboratory at Livermore. In addition, a substantial laboratory effort was devoted to the design and fabrication of test devices for the AEC's underground and atmospheric test programs; analysis of the test results from these experiments and the application of this knowledge to current and future weapon designs have also been carried on concurrently.

The general research program which provides the base for the weapons development program has continued in 1962. Effort was continued towards improvement in weapons design in the areas of reliability, efficiency, vulnerability and safety. Research is being conducted with the objective of providing improved devices for installation in certain deployed nuclear weapons to prevent the possibility of unauthorized use.

Considerable effort also was devoted to the improvement of weapons diagnostic instrumentation that is used to collect test data from both the atmospheric and underground test programs.

Weapons Production

Under Presidential authorization, the production of nuclear weapons by the Atomic Energy Commission continued in 1962. The production effort was responsive to Department of Defense requirements such as providing warheads for new weapons systems, and for bombs that would permit a greater flexibility in methods of delivery. The new weapons produced during 1962 were of more modern design with improved effectiveness, reliability, and safety over weapons previously in the stockpile. The program for retirement of obsolescent weapons was also continued.

Weapons Tests

Underground Test Series—Nevada Test Site

The underground test series, initiated on September 15, 1961, after the Soviet resumption of atmospheric testing, continued into 1962. By the end of the year, the Commission had announced a total of 61 nuclear weapons tests of intermediate or low yield carried out at the Nevada Test Site, and in addition, one additional cratering event was conducted at the test site for the AEC's Plowshare program.[5] Of the 61 announced nuclear weapons tests (including two low-yield United Kingdom devices), 57 were underground, three were slightly above ground, and one was slightly beneath the surface. The Army conducted a training exercise, the Ivy Flats Operation, in conjunction with one of the three above-ground events. The exercise which involved both the nuclear detonation and the firing of conventional weapons was conducted under the supervision of the U.S. Continental Army Command.

The underground testing program has proved quite successful. In some experiments, tests underground have proven to have a distinct technical advantage as well as the advantage in containing rather than releasing radioactivity to the atmosphere. It must be recognized, however, that this manner of testing is an expensive process even though operational efficiencies have increased with our experience; also certain type tests such as effects tests and many high yield detonations can only be carried out in the atmosphere and in the environment to which they pertain and at their particular design yield. However, continued progress in higher yield and other type underground detonation is being pursued.

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[5] The Plowshare program is administered by a separate division—the Division of Peaceful Nuclear Explosives—and has no relationship to the Division of Military Application which is responsible for the weapons program. The cratering event was not a part of the nuclear weapons test program although it did occur at the Nevada Test Site.

Weapons Tests in the Atmosphere (DOMINIC)—Pacific Area

Preliminary plans were under discussion during early 1962 leading to a sea-based atmospheric test series in the Pacific. However, in February 1962, agreement was reached by the United Kingdom and the United States on use of Christmas Island and emphasis shifted to a land-based operation. The President announced on March 2 the United States intention to resume atmospheric testing, in the absence of a nuclear test ban treaty, and plans were developed to proceed with a test series based primarily on Christmas Island, with missile-launching and some other events to be based on Johnston Island.

The President authorized the resumption of atmospheric testing on April 24, 1962, and the first event of the Pacific series was conducted on April 25, 1962. A total of 36 announced events were carried out through the completion of the series on November 4, 1962. Of the 36 events, 24 were air drops from planes based on Christmas Island; the remaining 12 events were: 5 high altitude events based on Johnston Island, 5 airdrops based on Johnston Island, one underwater event in the eastern Pacific Ocean area, and the other a test of the submarine-launched Polaris missile in the Christmas Island area.

Weapons Facilities

The Sandia Corp. research organization has moved into a new 3-story addition to the Sandia Research Laboratory building at Sandia Base, Albuquerque, N. Mex. The added space for the vigorous research program in weapon components provides centralization of the research facilities and organization.

Detection of Nuclear Explosions

Studies continued on ways and means to improve detection techniques and systems, both for underground and space applications. The Commission is participating in the VELA program, which is supervised by the Advanced Research Projects Agency (ARPA) of the Department of Defense, to improve the capability of detecting, locating, identifying nuclear detonations. The aim is to develop a system capable of adequately monitoring a nuclear test ban.

VELA UNIFORM Program

The purpose of the VELA UNIFORM Program is the development of techniques for improving the capability of detecting and identifying underground nuclear explosions. As planned, the Department of Defense is to have technical responsibility for the program and the Commission responsibility for:

1. Preparing for and firing all nuclear events.
2. Making all yield measurements and conducting any necesary post-shot drilling.
3. Obtaining close-in measurements for the decoupled events that are necessary to establish cavity behavior and the transmission of signals to the immediately surrounding earth.
4. Taking all steps necessary to assure public safety.

No nuclear detonations have been authorized to date solely for the VELA UNIFORM research program; however, information on seismic signals generated by underground detonations has been obtained from the weapons test series at the Nevada Test Site.

Project SHOAL

Project SHOAL, if authorized, will involve a nuclear detonation with a yield of approximately 10 kilotons solely for VELA UNIFORM purposes. It would be detonated 1,200 feet underground in granite in an active seismic area with the objective of comparing signals from a nuclear detonation with natural disturbances. A site for the detonation in the Sand Springs Area of Nevada (28 miles southeast of Fallon), has been selected.

Project DRIBBLE

Project DRIBBLE was originally planned as a series of nuclear detonations, solely for VELA UNIFORM purposes, in a salt dome. Because of the priority of the weapons test program this project was held in abeyance for some months. The DRIBBLE program is moving forward as a joint AEC–DOD program with the DOD having the administrative, funding, and technical responsibilities and AEC having the construction and firing responsibilities.

The Tatum Salt Dome, Mississippi (20 miles southwest of Hattiesburg) was explored and found suitable for the program. Planning is under way for three underground nuclear detonations, if authorized, at a depth from 2,000 to 2,700 feet below the surface. Current planning calls for two 100-ton and one 5-kiloton detonations. If a decision is made to go ahead, it is anticipated that the first detonation would be authorized for mid-1963, and the remaining two within the following months.

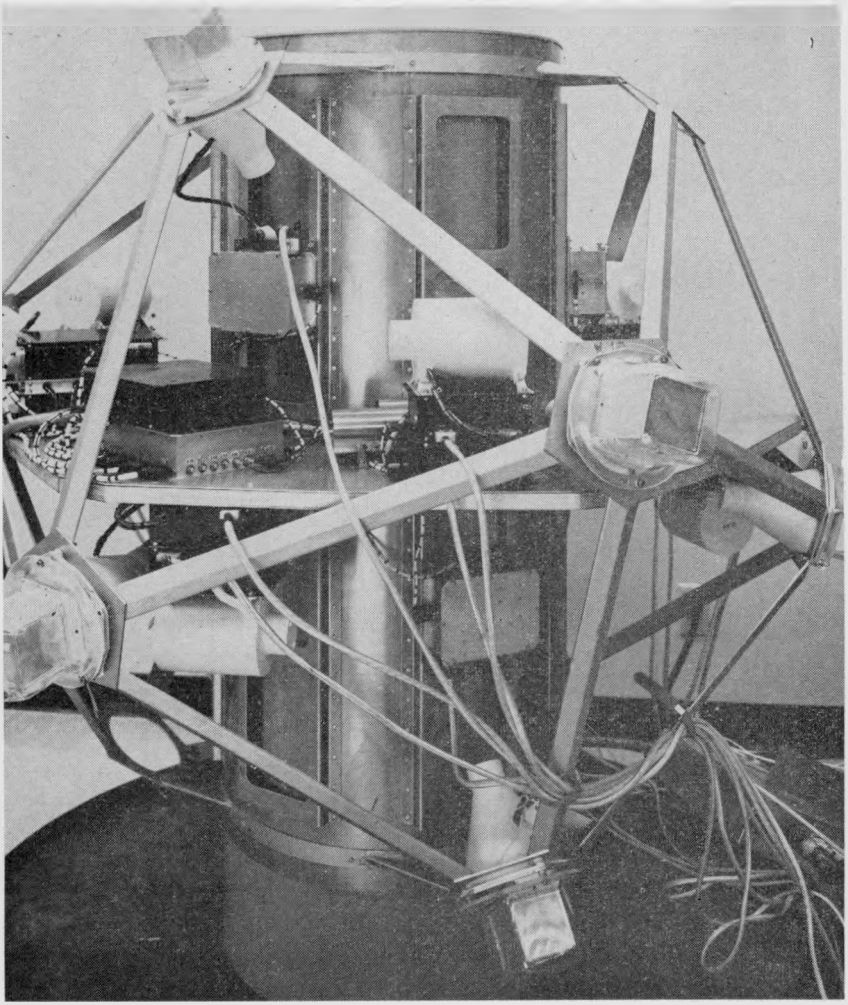
VELA–HOTEL Program

The Commission, through Sandia Laboratory and the Los Alamos Scientific Laboratory, is participating in the Department of Defense VELA-HOTEL Program, a research and development effort aimed at developing satellite-based instruments and systems to detect nuclear explosions in space.

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The current program now calls for five Atlas Agena launchings in 1963–64, each to put two instrumented satellites into earth orbits. In addition, instrumentation is being included on other space vehicles to measure background radiation at various levels above the earth.

The program of developing instrumentation for satellites for the Atlas Agena launchings is a cooperative effort by Los Alamos Scien-



VELA-HOTEL Satellite. As part of the joint Atomic Energy Commission-Department of Defense VELA-HOTEL program for developing the means of detecting nuclear explosions in space, few satellites carrying detection instruments are scheduled to be put into earth orbits during 1963–64. Photo shows a partially-completed VELA-HOTEL satellite. The square instruments on the framework are X-ray detectors and the cylindrical instruments near the satellite body are gamma-ray detectors. The device will also carry neutron detectors.

tific Laboratory and Sandia Laboratory. Radiation detectors for neutrons, gamma rays and X-rays will be employed.

VELA-SIERRA Program

The Los Alamos Scientific Laboratory is participating also in the Department of Defense VELA-SIERRA Program to develop ground-based instruments for detection of nuclear explosions in space. An experimental detector station using air fluorescence as a signal was field tested in the DOMINIC high altitude events, and detailed measurements of basic interest were made. This system is based on the detection of the fluorescence of nitrogen when bombarded by X-rays. An experimental direct-optical detection station was given some laboratory testing and was also tested in DOMINIC. This method utilizes an optical system to measure the visible light produced by a nuclear detonation.

MUTUAL DEFENSE AGREEMENTS

Exchanges of information under Agreements for Cooperation with other nations for mutual defense purposes continued during 1962.

The United States has mutual defense agreements in effect with Australia, Canada, Belgium, France, the Federal Republic of Germany, Greece, The Netherlands, Turkey, Italy, the North Atlantic Treaty Organization (NATO), and the United Kingdom. The U.S.-U.K. agreement, which is considerably broader than other agreements, involves the exchange of classified information on nuclear weapons, as well as the exchange of visits between scientists of the two countries.

Part Four

Other Major Programs

PLOWSHARE PROGRAM

The Commission's Plowshare program encompasses research and development looking toward the application of nuclear explosives in such fields as science and industry. The multitude of potential uses ranges from canal construction, excavation of harbors, recovery of low-grade minerals, processing of chemicals, to desalinization of water. Explosions for such purposes can be divided into two broad categories—cratering and confined explosives.

Status and Plans

In 1962, one nuclear cratering experiment, Project Sedan, was carried out, the task of analyzing the data from project Gnome [1] was under way, significant progress was made toward understanding problems of both cratering and contained explosions, and several future experiments were under study and development. Excavation, mining, and certain isotope production applications for nuclear explosives may soon be demonstrated as being practical and capable of making a substantial contribution to the economy. Power production now appears less certain of practical realization. Oil and gas recovery, and industrial scale chemical reactions are insufficiently understood as yet for a complete evaluation.

For scientific purposes, the nuclear explosive is a proven and versatile tool. As a result of the Project Gnome detonation of December 10, 1961, plans are underway for utilizing the unique effects of the nuclear explosive to further scientific research. As experience is gained and experimental techniques are developed, the scientific use of nuclear explosives should become even more important.

Project Sedan and previous chemical and nuclear explosive experiments have advanced understanding of nuclear cratering to such a point that:

1. A refined technology for excavation with nuclear explosives appears possible within about the next 5 years.
2. There are now assurances that future applications will not be seriously restricted by hazards from radioactivity.

[1] See pp. 208–215, "Annual Report to Congress for 1961."



Project Sedan Crater. The development necessary for using nuclear explosives in large-scale excavation projects was substantially advanced on July 6 when a 100-kiloton thermonuclear explosive, buried 635 feet beneath the Nevada desert, created a crater 320 feet deep and having an average diameter of 1,280 feet. Called Project Sedan, the detonation was part of the Commission's Plowshare program which is concerned with developing peaceful uses for nuclear explosives. This air view also shows the smaller craters from previous high explosive and nuclear explosive detonations. The three craters across center of picture, *left to right* are: the Plowshare program's Scooter event of 1960; the Jangle-U detonation of 1951; and Teapot ESS detonation of 1955. Jangle-U and Teapot ESS were conducted as part of the AEC-Department of Defense weapons effects test program. Across the top of the photo, are the three craters resulting from the Plowshare program's Stagecoach series in March 1960 which involved high explosives. (These craters are shown in better detail in photo on *opposite* page). The Sedan experiment was designed to extend scientific knowledge of cratering effects to the 100-kiloton range. Most nuclear excavation projects, such as harbors and canals, would require the use of explosives in the 100 kiloton to 10 megaton range.

TEAPOT ESS – 1.2 KT
Depth of burst
Apparent radius
Apparent depth
Height of lip
Date of shot – 3 March 1955
Various charges – some 256 lb. spherical charges of TNT, fired over a wide range of scaled depths of burst
STAGECOACH – 40,000 POUNDS H.E.
Depth of burst
Apparent radius
Apparent depth
Height of lip
Date of shot – March 1960
STAGECOACH – 40,000 POUNDS H.E.
Depth of burst
Apparent radius
Apparent depth
Height of lip
Date of shot – March 1960
STAGECOACH – 10,000 POUNDS H.E.
Depth of burst
Apparent radius
Apparent depth
Height of lip
Date of shot – March 1960

3. The amount charged for nuclear explosions should be considerably less in the future than the presently published estimates.
4. A preliminary theory of cratering has been developed by AEC scientists.

Field Experiments

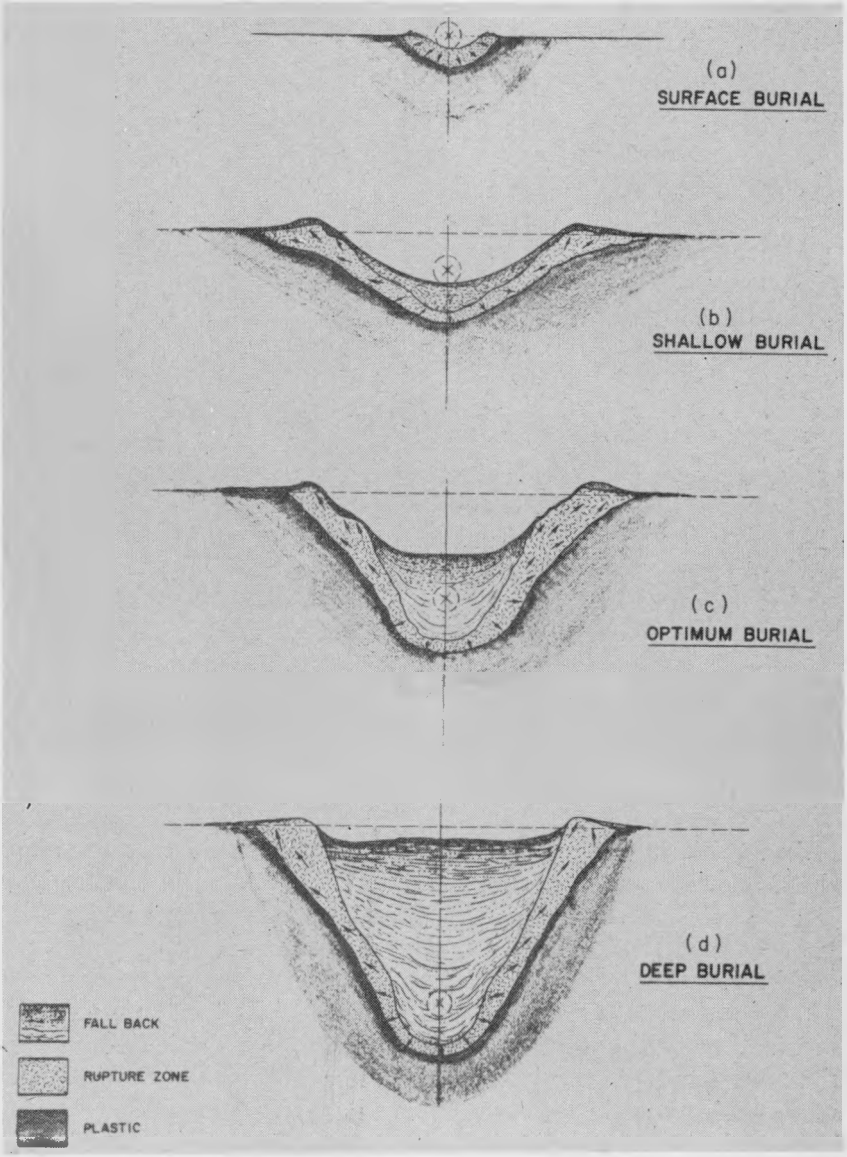
Two series of field experiments are being designed to extend and test theory in more stringent and restrictive cases. The experiments will proceed along two parallel, but different lines of development. The first series, Projects Sedan, Buggy, Schooner, Dogsled, Galley, Phaeton, and Chariot, is to further the understanding of nuclear excavation. The second series, Projects Gnome, Coach, and related activities consists of general development experiments, wherein nuclear explosives are detonated to obtain valuable scientific information and to evaluate potential applications of contained explosions. All of the cited projects are described in more detail below.

CRATERING EXPLOSIONS

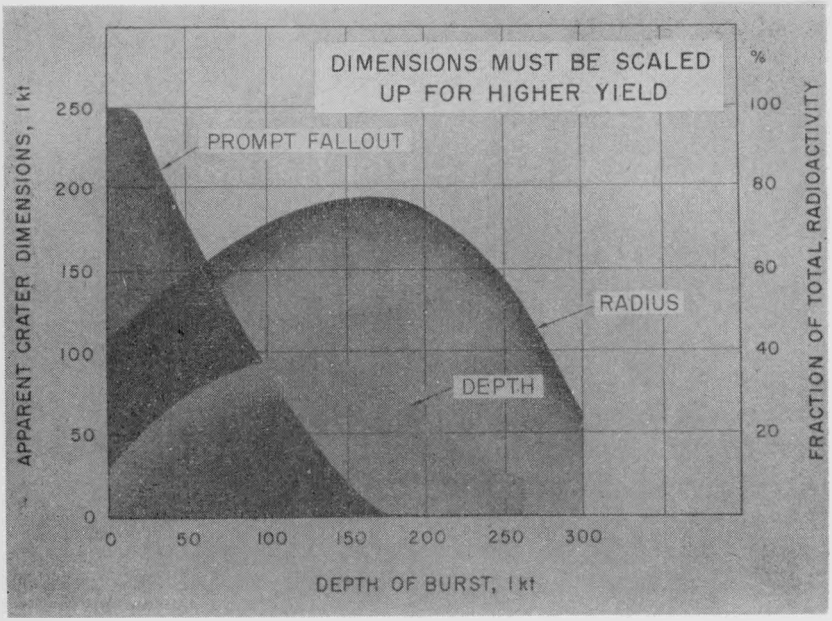
Of all the potential peaceful applications, perhaps the most obvious, certainly the best understood, and probably the most certain of being accomplished with large economic gains is earth-moving. The nuclear weapon test program over the years has included several nuclear detonations which produced craters. In addition, well over a hundred craters have been created with chemical high explosives (HE) in the Plowshare program. The data from these nuclear- and HE-produced craters indicate that nuclear explosives can be used safely and with great savings in costs and time in construction projects which require large scale earth-moving. Other uses for crater-producing detonations are open-pit mining, construction of reservoirs, and diversion canals for water resource development.

Crater Characteristics

The characteristics of craters produced with explosives vary with the depth of burial, the type of earth and the power (yield) of the explosive. The effect of deeper burial on the crater is shown pictorially in the drawing "*Crater Profiles*" and graphically in the radius and depth curves of the chart "*Radius vs. Depth.*" In general, the craters are wider and shallower at deeper depths of burst.



Crater Profiles. The characteristics of craters produced with explosions vary with the depth of burial of the explosive as well as the type and power of the explosive. Drawing above shows typical crater profiles *vs* depth of burst for alluvium soil. In general, the creaters are wider and shallower at deeper depths of burst.



Radius vs Depth. The *above* graphical representation shows how the amount of prompt fallout and the radius of a crater will vary with the depth of burst figured on the basis of a one kiloton explosive. For higher yield explosives the data must be scaled up.

Effect on Radioactive Fallout

As the depth of burst is increased not all the earth and rocks above the detonation point are thrown out as is illustrated in the drawing. The material in the fallback, or rubble, zones serves the important function of acting as a filter which reduces the escape of radioactive debris. Because of the selective nature of this rubble zone filter, most of the particulate and condensable gaseous debris is entrapped. This includes the solid precursors of fission products such as iodine 131. On the other hand, gaseous isotopes and their decay products will escape more readily and in higher percentages than the particulate debris. Two typical examples of fission products which have gaseous precursors are strontium 90 and cesium 137. In addition, the small fraction of the debris which escapes through the rubble zone will have lost much of its momentum and will have been in intimate contact with dust particles to which it may adhere. Consequently, most of the debris will fall back to the ground close to the point of detonation.

For low yield nuclear detonations buried at optimum depth it has been observed that only about 5 percent of the radioactivity is released and this is deposited locally—that is, it does not enter the worldwide fallout system. By designing large excavation projects to incorporate

these entrapment phenomena, the radioactivity can be held to manageable levels. Device designs currently under study are leading to nuclear explosives which obtain less energy from nuclear fission, thus further reducing the amount of fission products to be controlled.

At optimum depth of burial the rubble zone also serves to suppress the thermal or fireball effects and reduces the possibility of air blast damage. Hazards from seismic shock are limited to close-in ranges. These effects however must be evaluated before each detonation.

Excavation Experiments

The first nuclear excavation experiment in the Plowshare program, Project Sedan, was conducted on July 6, 1962, at the Nevada Test Site (NTS). In addition, a weapons effects cratering experiment,[2] called Project Danny Boy, had been previously conducted at the NTS on March 5, 1962, and provided most of the data which would have been sought from the previously planned Project Wagon. These two experiments confirmed the broad expectation that in hard, dry rocks such as basalt, nuclear explosions will produce about the same size craters as equivalent amounts of high explosives; and for desert alluvium, that crater size information which had been previously obtained at low yields could safely be extended to the 100 kiloton yield ranges. It was also confirmed that the major part (more than 90 percent) of the radioactivity produced by cratering explosions is contained below the surface of the earth.

For the next 4 years, it is planned that nuclear excavation experiments will be conducted at the rate of about two per year. At the end of that period, a completed theory for cratering should have been developed and tested and there should exist the technology for carrying out construction projects with particular engineering requirements.

PROJECT SEDAN

Project Sedan, a 100 kiloton nuclear cratering explosion, was conducted under the Plowshare program at the Nevada Test Site on July 6, 1962. The purpose of Project Sedan was to extend knowledge of cratering effects to the 100 kiloton range of yields, since the majority of previous cratering experience had been limited to low yields. Most large nuclear excavation projects such as harbors and canals

[2] The Commission's Plowshare program is administered by the Division of Peaceful Nuclear Explosives. On the other hand, nuclear weapons and weapon effects tests are a joint effort between the Commission's Division of Military Application and the Department of Defense. In those instances where a nuclear weapons or weapons effects test can furnish information of usefulness to the Plowshare program, the Division of Peaceful Nuclear Explosives will arrange to participate in the collection of data resulting from the test. In general, however, Plowshare program activities are divorced from activities of the Division of Military Application.

would require the use of nuclear explosives in such higher ranges. Sedan was also designed to provide data on safety problems related to radioactivity, seismic effects, and air blast; and to provide answers to technical questions concerning the prediction of results, especially crater sizes.

Technical Plans

The depth-of-burst chosen for Sedan was 635 feet. Previous data had indicated that this depth would result in a crater of almost maximum dimension while allowing less than approximately 5 percent of the radioactivity produced by the explosion to escape. The location chosen at the Nevada Test Site was near the nuclear craters of Jangle U and Teapot ESS of the 1951 and 1955 weapons effects test series and much high explosive cratering work such as the Scooter and Stagecoach events of 1960.

The 100 kiloton explosive used for Sedan was a thermonuclear device in which less than 30 percent of the energy released came from fission. Measures were taken to reduce the radioactivity induced in the soil by the neutrons from the thermonuclear portion of the yield to a level well below the amount of fission products produced. With less than approximately 5 percent of the radioactivity escaping from the ground, the radiation was expected to be less than that produced in a 2 kiloton surface explosion.

Technical programs accompanying the detonation included airblast and seismic monitoring both onsite and offsite. Scientific photography from five camera stations was used to determine surface motion and cloud dimensions.

Fallout trays and collectors were positioned throughout the anticipated fallout sector and bioenvironmental plots were laid out to study radiation effects caused by the explosion. Radioactive pellets, as tracer materials, were emplaced in holes near the shot point to study particle trajectories. Tarpaulins, trays, and measuring rods were distributed to measure and document the distribution of the throwout and dust.

Immediate Effects

When Sedan was detonated a roughly hemispherical dome of earth, 600 to 800 feet in diameter, rose to a height of 290 feet within 3 seconds after the detonation, at which time venting of incandescent gases occurred.

The earth and rock continued to rise to a height of about 2,000 feet. As this tremendous mass of earth fell back to the ground, a base surge

was formed and later expanded radially to a distance of approximately 2.5 miles crosswind and 2 miles upwind.

The cloud rose promptly to 12,000 feet and then its spread eventually reached a height of about 14,000 feet above the desert floor.

Quarter-mile Crater

The crater formed has a maximum depth of 320 feet and an average diameter of 1,280 feet. The lip heights ranged from about 20 to almost 105 feet. About 7.5 million cubic yards, or about 12 million tons, of earth was displaced by this single detonation.

The cloud was carried downwind by a 19-knot wind blowing from South-Southwest. Intense fallout was confined to approximately two miles upwind and crosswind, and four miles downwind, from ground zero. The estimated maximum infinite radiation doses which a person living continually 50 to 100 miles away could have received in a lifetime were about 2 roentgens and 20 milliroentgens, respectively. Decay of radioactivity from such detonations is very rapid; for example, workers returned for short periods to the crater lip 5 days after the detonation.

Other Results

Integration of the fallout pattern indicates that less than ten percent of the radioactivity was released as prompt fallout, thus verifying that models for the prediction of vented radioactivity remain much the same at large yields as at small yields.

Ground shock intensities were much less than expected from previous experience in tuff and alluvium. Accelerations of only 0.1 g were recorded at a distance of approximately 1.5 miles from ground zero.

Air blast stations in the caustic range (80 to 150 miles) recorded peak pressures up to 0.83 millibar at China Lake, Calif., some 137 miles southwest of ground zero. These pressures were due primarily to the ducting of the blast wave in the ozonosphere. (Winds from 80,000 to 150,000 feet were easterly, with speeds up to 104 knots.) The airblast was attenuated an average of about sixfold because the explosive was buried in the earth.

Analysis of radioactive debris from Sedan by the Lawrence Radiation Laboratory (Livermore, Calif.), of meteorological data by the U.S. Weather Bureau, and of samples of milk by the U.S. Public Health Service indicate that the Sedan experiment contributed only a small part of the iodine 131 found in Salt Lake City, Utah, milk during July and August.

RELATED EXPERIMENT

Closely complementing the data from Sedan were data of use to the Plowshare program derived from Project Danny Boy, a low-yield weapons effects cratering experiment conducted by the Department of Defense in basalt at the Nevada Test Site. When the project was detonated on March 5, 1962, instrumentation was included to make measurements for the Plowshare program. This experiment was similar to one planned earlier in the Plowshare program called Project Wagon which has now been cancelled since the primary data have been obtained.

The primary objectives of the Plowshare participation in the experiment were twofold:

1. To determine the cratering characteristics of nuclear explosions in a hard, dry, inert medium such as basalt.
2. To determine the amount, distribution, and decay of radioactivity released by a nuclear cratering detonation buried near optimum depth of burst in a hard rock medium.

Other information was to be obtained on (*a*) shock pressure *vs* distances in basalt, (*b*) seismic shock at various ranges, and (*c*) close-in and long-range airblast attenuation.

The depth of burst (distance from surface to the device) was 110 feet and the yield was about 0.4 kilotons (400 tons). The resulting crater has a radius of 107 feet and a depth of 62 feet. A base surge about 2,900 feet in diameter and 1,000 feet high was produced. The dust cloud diffused to a height of 2,000 feet after approximately 30 minutes. About 5 percent of the radioactivity was released as fallout; however, over 90 percent of this small fraction was deposited within 2 miles of ground zero.

FUTURE EXCAVATION EXPERIMENTS

Project Buggy

Project Buggy is an excavation experiment planned to be conducted in alluvium at the Nevada Test Site. Five nuclear explosives, each with a yield of about 10 kilotons, will be detonated simultaneously, probably in 1963. This experiment is designed to provide information on the interaction of several simultaneous detonations. The shape and size of the resultant ditch, as well as information on fallout, seismic shock, and airblast will be obtained.

The basis for the experiment is the indication from high explosive tests carried out in 1959, 1960, and 1961 that two potentially important phenomena are associated with the simultaneous detonation of

a row of charges. These phenomena are an enhancement of ditch size and a virtual lack of throwout at the ends of the ditch. Such phenomena would be quite important in the construction of canals. It is expected that the elongated ditch will be about 2,300 feet long, 700 feet wide, and 125 deep, with a pronounced ridge of ejected material along each side. Somewhat less than 10 percent of the total radioactivity produced should enter the downwind fallout pattern. The explosives will probably be thermonuclear, so the amount of radioactivity released would be equivalent to less than this 10 percent of the total yield.

Project Schooner

The Schooner experiment is being designed to obtain cratering information for high-yields in a hard, inert rock. Small variations in crater shape noted in the Danny Boy experiment may be very important when excavations requiring megatons of yield are conducted in such hard rock. In order to confirm that cratering information obtained from high-explosive experiments and from Danny Boy are valid when scaled to large yields in hard rock, it is proposed to detonate a nuclear explosive with a yield of about 100 kilotons in granite. The explosive will be designed especially to produce a minimum of radioactivity and will be buried so that only a small percentage of this radioactivity escapes. The crater formed is expected to be about 1,100 feet in diameter and 300 feet in depth, with a volume of about 7,000,000 cubic yards.

Project Dogsled

Experiments conducted several years ago with high explosives indicated that under identical conditions craters produced in sandstone rock were much smaller than in other rock types. The Dogsled experiment would provide data on crater dimensions for a high yield nuclear cratering explosion in sandstone. These would be comparable to the dimensions, or cratering efficiency, determined in alluvium (Sedan) and in granite (Schooner). The project is still in preliminary planning stages and no site has yet been proposed.

Project Galley

Galley would be a multiple-charge experiment in hard rock and would provide data on the cratering effects of a row of nuclear explosives simultaneously detonated in hard rock under terrain of varying elevations.

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Project Phaeton

The Phaeton experiment would consist of the detonation of a megaton device in the later stages of the experimental excavation program. Site selection studies for this project will be undertaken in the near future. The experiment will extend knowledge of crater scaling and radioactivity entrapment to the megaton yield range.

Project Chariot

During 1962, the Commission reviewed its plans for Project Chariot, a proposed nuclear excavation experiment on the Northwest Alaskan coast near Cape Thompson. The experiment was designed several years ago to provide scientific and engineering data for excavation projects. Specifically, information was to be sought on: cratering laws, the effects of row charges in the nuclear yield range, and the effects of radioactivity, airblast and seismic shock on the environment near the site.

Some of the data originally planned to be obtained from Chariot are now available or are expected to be developed from other planned experiments. As new data are developed they will be evaluated with respect to their possible influence on the role the Chariot experiment could play in the overall experimental excavation program. In view of the present dynamic situation, the Commission has deferred for the present, any decision to cancel the project or to recommend to the President that it be conducted. In the meantime, the site has been placed on a caretaker status and will be available for use in the interim for other scientific investigation purposes.

Environmental studies completed. The more than 40 bioenvironmental studies which have been carried out in the proposed Chariot experiment area since the late spring of 1959 were concluded in August. This work, supported primarily by the Plowshare program, was intended to provide a basis for evaluating the effects of the detonations on the ecology of the region. A second Summary Report [3] prepared by The Committee on Environmental Studies for Project Chariot has now been issued. It is planned that in 1963 a complete scientific report on these intensive environmental investigations will be published.

The Committee's Second Summary states "We believe the many reviews of the data and consultations with many scientific people, warrant the conclusion that if the detonation were carried out the

[3] Copies of this report are available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., $2.75.

chance of biological cost at the ecological level, including jeopardy to the Eskimos or the plants and animals from which they derive their livelihood, appears exceedingly remote. There are necessarily some uncertainties involved in some predictions, however, that can be resolved only by experimentation."

The Committee goes on to say, "Radiation effects on biota pose different and, in some respects, unique problems, even though it would appear that they would be slight, undetectable or possible non-existent beyond the throw-out boundary. This is given additional credence by the long studies at Nagasaki and Hiroshima, and of the Rongelap people and environments."

CONTAINED EXPLOSIONS

Contained explosions are particularly useful for conducting certain kinds of scientific research and may also have certain practical applications.

Scientific Uses

The scientific application for nuclear explosives is one of the most stimulating activities under the Plowshare program since radiation, temperature, and pressure, not available from other sources, can be obtained from a nuclear explosion for experimental use. Neutron emissions are particularly useful and can provide insights and tests of theory of wide and basic usefulness. In this area, it seems possible that a threshold has been reached with contained detonations not unlike that encountered when the usefulness of the particle accelerator ("atom smasher") as a research tool was first beginning to be understood.

Practical Uses

Among the practical applications for contained explosions are: the mining of ore by the crushing of mineral deposits for leaching or block caving; the development of water resources by creating underground reservoirs and by fracturing strata blocking the connection of the surface to aquifers; the liberation of oil in deposits where it is otherwise unavailable; the processing of chemicals in raw form in the earth; the production of isotopes; the production of electric power; and the production of process heat for water desalinization or other purposes. Evaluation of these ideas requires more technical informa-

tion than presently available. Therefore, a series of experiments, planned for execution at the rate of about one per year, has been designed primarily to obtain information about the interaction of buried nuclear explosions with the earth under a variety of conditions. Already, from the results of Project Gnome and from computation efforts, it has been possible to conclude that production of electrical power in salt cavities is not likely to be competitive with more conventional techniques.

ASPECTS OF CONTAINED EXPLOSIONS

Contained nuclear explosions can be produced under conditions such that all or practically all of the radioactivity is trapped underground. This is an important point from the public safety and operational standpoints.

Seismic shock and ground motion, two other effects of contained nuclear explosives, can be dealt with rather easily by selecting locations sufficiently remote from sensitive structures to avoid damage. Effects from airblast are almost completely suppressed since the explosion is contained.

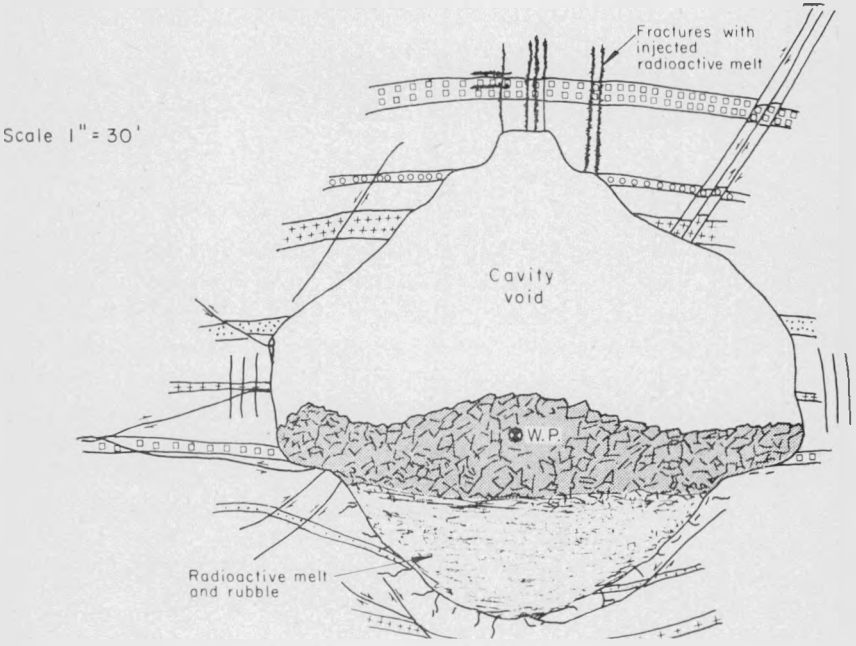
A principal focus of studies regarding contained nuclear explosions is the possible contamination of ground water—especially in water resource applications. Among several safety-oriented studies in the Plowshare program there has been a continuing effort to study potential ground-water contamination. These studies, conducted over the past 4 years, have led to the development of techniques for the computer prediction of the flow of radioactive contamination from nuclear explosions. Due to the adsorptive nature of rock and soil surfaces and to the dispersive nature of ground water, radioactivities do not move as fast as water. Further field tests of these phenomena are planned as future efforts. One of these studies, "Research on Radioactive Contamination of Ground Water Acquifers," is being conducted for the Lawrence Radiation Laboratory by the Texas A&M College, College Station, Tex.

FIRST EXPERIMENT

Project Gnome was the first nuclear detonation executed under the Plowshare program. While the detonation occurred more than a year ago (December 10, 1961), valuable data continues to be derived from the experiments conducted in conjunction with Gnome. The basic source of energy for the experiment was a 3.1 ($\pm$.5) kiloton nuclear explosive emplaced in a salt bed, 1,200 feet underground near Carlsbad, N. Mex.



Project Gnome Cavity. Project Gnome was the first nuclear detonation conducted under the Plowshare program when a 3.1-kiloton explosive was detonated on December 10, 1961, in a salt bed 1,200 feet underground near Carlsbad, N. Mex. Entry to the resultant cavity was made on May 17, 1961, through an underground cut parallel to the original tunnel. The force of the explosion resulted in a cavity hemispheric in shape measuring about 160 to 170 feet in diameter and 60 to 80 feet high. The salt comprising the cavity walls was colored shades of blue, green, and violet by the intense radiation present immediately after the detonation. Photo shows John Brewer of the Lawrence Radiation Laboratory (Livermore) staff standing on the rubble that spalled off the cavity walls. The lower half of the cavity is filled with solidified melt and rubble, water, and fragments and blocks of rock. Diagram *below* shows the shape of the cavity.



Cavity Entry

It has been possible, as a result of mining explorations into the detonation area, to establish the details of the huge cavity created by the explosion. Workers, upon entering this cavity on May 17, found temperatures around 140° F. but only small amounts of residual radiation. The salt comprising the cavity walls had been colored shades of blue, green, and violet by the intense radiation that had existed earlier.

Steam Venting

Shortly after the Gnome detonation at noon (MST), December 10, 1961, steam escaped from the cavity, through the tunnel to the shaft and into the atmosphere. The venting was caused by the very rapid breakup of the rock-salt formation surrounding the detonation area. This created an opening between the cavity and the emplacement tunnel instead of closing the tunnel as had been planned. As a safety precaution, a plug had been placed in the tunnel about 900 feet from the detonation area and filters had also been installed. The barriers slowed the leakage and filtered out almost all of the particulate radioactivity. As a result, escaping steam contained mostly short-lived gaseous radioisotopes.

Due to the leaking, no comprehensive thermal energy measurement program was possible. Other experiments, however, established that the steam contained large amounts of corrosive and acid materials so that operation of turbines would require difficult and expensive engineering. Tentatively, it can be concluded that the use of nuclear explosives for power production in salt cavities is neither technically nor economically attractive.

Isotope Production

Studies of the chemical and physical distribution of the isotopes from Gnome have been nearly completed. The nongaseous isotopes, especially those of uranium, plutonium, and the transplutonium elements such as americium and curium are found associated with the insoluble silicates and metal oxides which are distributed as impurities throughout the salt. It appears possible that, either by dissolving away the salt or by separating the more dense isotope-containing material from the less dense salt in cyclone separators, these isotopes could be isolated. The volatile isotopes, especially the valuable hydrogen isotope, tritium, were distributed in the steam. If a nuclear explosive designed to produce large quantities of tritium were detonated

in a salt dome with a relatively low water content, it appears that it may be possible to recover tritium.

Chemical Transitions

Samples of various minerals, and rocks, including oil shale, and oil sand, were exposed to strong shocks by emplacing them in drill holes near the Gnome detonation point. Analysis of these samples has indicated that the chemicals undergo transitions to new compounds as a result of the high pressure and temperature. The samples are being studied to determine what value, if any, these new compounds may have.

Nuclear Transformations

Analysis of samples exposed to the neutrons emitted during the explosion has led to the discovery of one new nuclear energy level in hafnium 85, and has brought forth a changed understanding of the fission process. These experiments, many of them of a basic research type, are of great scientific importance. A detailed summary of the basic research results of the Gnome experiment will be included in the Commission's Annual Report on "Fundamental Nuclear Energy Research--1963" which will be published in late 1963.

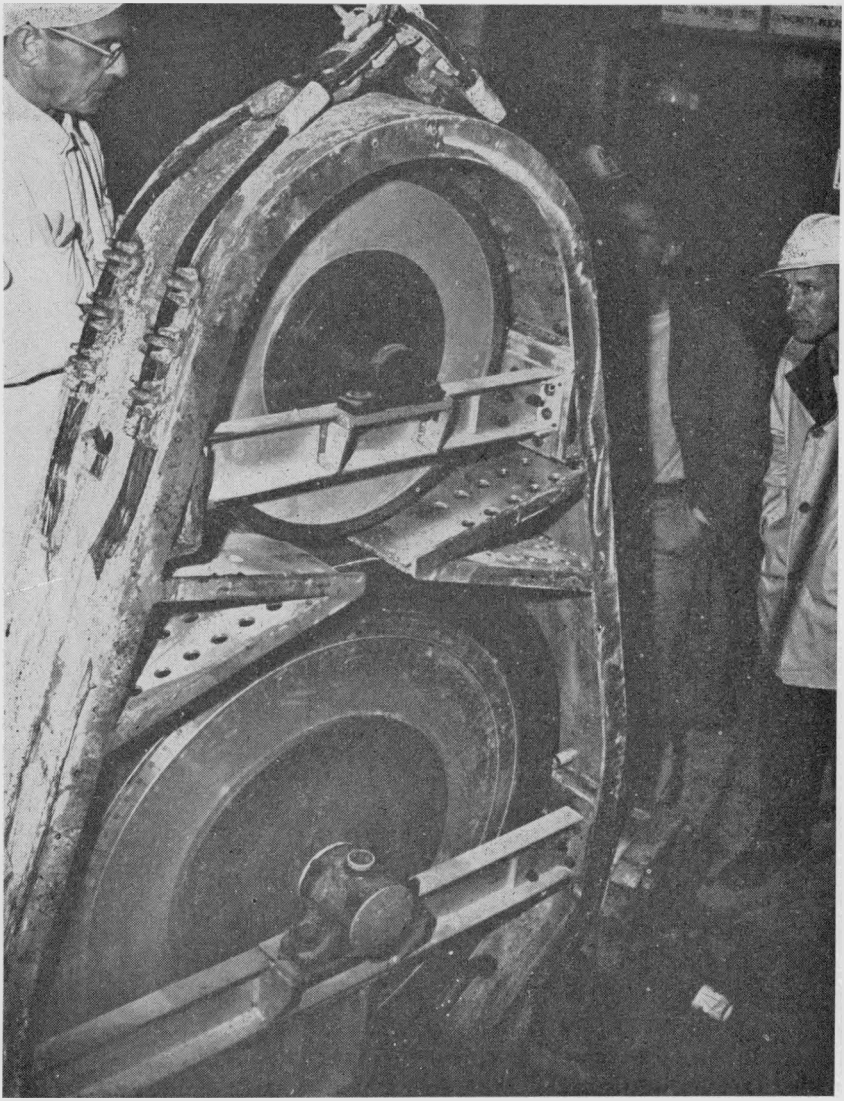
Technical Reports Available

The wealth of scientific data derived from Project Gnome will be contained in over 30 technical reports about Gnome. To date, about 15 final reports have been published while over 15 more are being prepared for 1963 publication. As published, copies of these reports are available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.

In addition, the data from Gnome continues to provide the basis for additional scientific investigations, some of which are reported in the December, 1962, issue of the Bulletin of the Seismological Society of America.

Pressure Waves

This explosion in salt created pressure waves which traveled through the earth in all directions. At the long ranges, the waves were attenuated by different factors toward the east and north than toward the west and south. The velocity of the first arriving wave in the 125 to 500 mile range was also different from that expected by



Neutron wheels. Analysis of samples exposed to neutrons emitted during the Project Gnome detonation has led to some changes in understanding of the fission process. Photo shows the neutron wheels which made neutron cross-section measurements, one of the five technical objectives Gnome, after their recovery from the tunnel 1,200 feet beneath the New Mexico desert. The upper wheel had a uranium 235 foil ring for a Los Alamos Scientific Laboratory neutron experiment. The lower wheel had concentric rings of uranium 238 foils, thorium foils, and an inner ring of gold and hafnium foils. It was prepared by Lawrence Radiation Laboratory (Livermore). The neutrons from the explosion passed through a lead attenuator before striking the electric motor-driven wheels.

seismologists, being as high as 5.2 miles/second. The crustal velocity in the great plains regions was 4.0 miles/second and the Mohorovicic discontinuity (Moho)[4] was calculated as 30 miles below the surface of the earth in the central United States. This information has been of great interest to the geophysicists studying the earth through seismic measurements. Closer to the detonation point, ground displacements were very nearly identical to those calculated, being about 2½ inches at 900 feet and varying as the inverse of the square of the distance.

RELATED EXPERIMENT

Another Department of Defense weapons effects experiment which is contributing significant data for the Plowshare program was carried out on February 15, 1962. This was a 5 kiloton nuclear explosion, called Hardhat, conducted in a granite-type rock at NTS. The explosive was buried 950 feet. Since the detonation was to be in granite, Plowshare scientists added a number of experiments to the program.

Upon detonation, a cavity 63 feet in radius was formed. Lining this cavity were several hundred tons of molten granite. New mineral forms produced by high pressure and temperature have been found in the rock beyond the cavity. The cavity, filled at first with hot vapor, slowly cooled until, about 12 hours after detonation, it collapsed, possibly because of the changing thermal stresses. This collapse led to the formation of a column of broken and crushed granite about 140 feet in diameter and over 350 feet high.

FUTURE EXPERIMENTS

In 1952, when the first large thermonuclear explosion (Mike) was detonated, at Eniwetok Atoll in the South Pacific, isotopes of several new elements were formed. Studies at several AEC laboratories led to discovery and characterization of two of these, einsteinium and fermium, elements 99 and 100. Research into design of explosives has advanced now to such a point that special low energy explosives which optimize the flux of neutrons can be built.

Project Coach

The first experiment planned to make use of such an explosive which will create an intense flux of neutrons in a uranium target, and thus

[4] The major discontinuity throughout the world between the upper mantle and the crust; it is located about 5 miles under the oceans and up to about 40 miles under the continents.

produce heavy isotopes of transplutonium elements and perhaps of new, undiscovered elements will be Project Coach. The isotopes produced will be of considerable value for scientific research in the field of nuclear chemistry, particularly the neutron-rich isotopes which can only be produced in quantity through such a multiple-capture mechanism. In addition to study and characterization of the properties of these isotopes it can be expected that this work will provide new and valuable insight and theory in this important field. The experiment will be conducted at the end of a tunnel originating from an extension of the vertical shaft used for the Gnome detonation near Carlsbad, N. Mex. Information derived from the Gnome studies is being used to design isotope purification and recovery techniques.

The explosion is planned to release somewhat less than 10 kilotons of energy and should create a cavity approximately 80 feet in radius with a pool of broken and molten salt filling its lower third to half. This pool should contain most of the radioactivities including the valuable transplutonium isotopes.

In addition to producing isotopes, Project Coach will allow study of the structure of the earth, the effects of strong shock on minerals and chemicals, and a confirmation of theoretical calculations. These experiments are extensions of those conducted as part of Gnome. From the Gnome results, and because the energy from Coach is of the same order as Gnome, no unusual safety problems are expected.

The date for the Coach experiment has not yet been finally established, although it is planned for 1963.

Related Experiments

Plowshare participation in VELA-UNIFORM events,[5] such as Projects SHOAL and DRIBBLE, may provide information of considerable value to Plowshare. The purpose of the VELA-UNIFORM program is the development of techniques for improving the capability of detecting and identifying underground nuclear explosions. Plowshare's participation would consist primarily of instrumentation and use of resulting data and, possibly, postshot exploration of the detonation regions.

Project SHOAL. When authorized, SHOAL will involve a nuclear detonation in granite with the objective of comparing signals from a nuclear detonation with natural disturbances. The site for

[5] See "Military Applications" section, Part Three.

the detonation is the Sand Springs area of Nevada (28 miles southeast of Fallon), which is an active seismic area.

Project DRIBBLE. DRIBBLE was originally planned as nuclear detonations, in a salt dome, solely for VELA-UNIFORM purposes.

The Tatum Salt Dome in Mississippi (20 miles southwest of Hattiesburg) was explored and found suitable for the program. Planning is underway for three underground nuclear detonations, if authorized, at a depth from 2,000 to 2,700 feet below the surface. Current planning calls for two 100-ton and one 5-kiloton detonations. It is anticipated that the first detonation would be authorized for mid-1963, and the remaining two within the following months.

GENERAL RESEARCH AND DEVELOPMENT

Laboratory research in the Plowshare program falls into two broad areas. The first is the study of results from field experiments and laboratory work, which leads to development of models for behavior of explosives under a wide variety of conditions. Computer codes and physical input to them have been developed to conform with the results of Gnome and other field experiments. Measurements of the properties of the appropriate rock (salt, granite, basalt, etc.) are used as input to these calculations. While several questions remain unanswered, accomplishments are now sufficient for prediction of most of the physical effects of explosions in various media under the range of most expected geological conditions.

The second area of effort is the application of these preliminary models to specific applications which may have a future practical value. An example of such an application is the possible utilization of the cheap heat of high natural geothermal gradients in the earth for desalinization of sea water. Rough calculations indicate that the cost of thermal energy that can be made available through fracturing hot rocks thousands of feet below the earth may be one-tenth or one-twentieth of the cost of heat from other sources. This type of water desalinization seems especially attractive since sources of geothermal heat of the required character are thought to be present in the southwestern and western United States.

Another example of this research is that conducted in meteorology, primarily in order to increase understanding of phenomena related to safety. In this case, because the formation of radioactive cloud influences the area which will become contaminated by radioactivity, a detailed computational study of cloud rise and base-surge formation

is under way. Inputs from the field, nuclear cratering experiments, and volcanic ash falls are being used to test the theory and to evaluate the physical parameters used in describing the atmosphere. It is also significant that much information of geophysical and meteorological importance is a byproduct of these efforts.

In a related effort, a series of small high-explosive charges containing radioactive tracers were fired in the summer of 1961 at a Lawrence Radiation Laboratory (Livermore) site near Tracy, Calif., under conditions simulating nuclear explosive excavations. This experiment, called Yo-Yo, provided additional data concerning the earlier tentative conclusion that less than five percent of the radioactivity produced by a cratering nuclear explosive would rise high enough into the air to become fallout, even though a nearly maximum-size crater was produced.

Explosive Device Development

The single most important research advance in the Plowshare program has resulted from studies of cheaper explosives designed to produce a minimum of radioactivity. It is now assured that large excavations free of serious radioactive contamination can be executed with nuclear explosives. Fission products and radioactivities induced by neutron capture have been reduced drastically in these new designs made especially for Plowshare purposes, and at the same time less expensive explosives have been produced. This results from the fact that explosives for Plowshare purposes need not have the severe design limitations that are imposed by weapons requirements.

In addition, development is underway to achieve device development with characteristics applicable to other peaceful uses such as the production of isotopes of heavy elements in Project Coach.

PROGRAM DEVELOPMENTS

The most significant development during the year was the establishment by the Commission of the program goal of developing nuclear excavation technology by the end of fiscal year 1967. The program which is underway to meet this goal has been described in the preceding sections.

Corps of Engineers Cooperation

Also, because of the possible utility of nuclear excavation techniques in large construction projects under the cognizance of the Office

of Civil Works of the U.S. Army Corps of Engineers, and because of the experience and capability of the Corps in civil engineering matters, it was considered to be to the mutual advantage of the two Federal agencies to collaborate more closely and formally in the development of this nuclear excavation technology. Agreement was reached between the two agencies on a division of effort in which the AEC conducts the experimental nuclear detonations, develops excavation and device technology, and performs safety and site surveys, and the Corps of Engineers conducts a collateral high-explosive, experimental program and develops engineering technology regarding such matters as slope stability and construction techniques in fracture zones.

This collaboration extends from joint program planning to technical liaison through the assignment of a Corps of Engineers group to the Lawrence Radiation Laboratory at Livermore, Calif. The liaison group also has responsibility for carrying out the Corps of Engineers part of the program. In addition to other advantages, it is expected that through this collaboration the Corps will acquire the capability to plan utilization nuclear explosives in excavation by the time this technique is perfected.

Canal Legislation

In a complementary step, legislation was introduced in Congress to authorize the Panama Canal Co. to conduct surveys of possible routes for the construction of a sea-level, trans-isthmian canal. This proposal, and the nuclear excavation program, are in keeping with recommendations that studies should be made to develop alternatives to insure the adequacy of facilities for the rapidly accelerating amount of traffic through the present Panama Canal.

PUBLIC SAFETY PROGRAM

In developing military and peaceful uses of nuclear energy, the Commission always considers the precautions necessary to protect the public from the effects of nuclear radiation or any other form of hazard or damage that may result.

Program Under Nevada Office

Responsibility for protecting the public and of project participants in matters of safety during and after such Commission activities as

the PLUTO and ROVER reactor experiments and all U.S. nuclear detonations is assigned to the recently established Nevada Operations Office formerly the Office of Field Operations. This responsibility extends to the conduct of the experiments and to their effects, including any release of radioactive products to the atmosphere or to ground water, seismic or ground shock, flash, and air blast.

The Nevada Operations Office, which is located in Las Vegas, is responsible also for assuring that all safety factors, particularly those of radiological concern are considered on a coordinated, knowledgeable, and systematic basis in planning tests and experiments. In the case of nuclear detonations, the Nevada Operations Office is charged with responsibility for carrying out the actual detonation operation as well as conducting the programs for industrial, environmental, and radiological safety.

Research and Study Projects

Additionally, the Nevada Operations Office also supervises the basic and applied research and study projects in hydrology, meterology, oceanography and many other areas of technology which bear on public safety as a result of tests and experiments. These research and study projects are carried out within the AEC, and by other government agencies in cooperation with the Commission, or by Commission contractors.

Earth science studies. During June, the Nevada Operations Office extended a contract with Roland F. Beers, Inc., Alexandria, Va., to continue long-range carefully selected, studies in the broad field of earth sciences. Under the contract, the contractor performs selective studies to improve predictions of hazards to public safety; correlates existing data; identifies gaps in existing knowledge; recommends programs for filling such gaps; and formulates methods for programs of selective research by others to improve theories and data.

Hazard predictions. Early in 1962, a contract was negotiated with the Hazleton-Nuclear Science Corp., Palo Alto, Calif., to undertake selective studies to improve hazards predictions. The contractor is to develop principles based on analysis of information collected from all available sources that may be used in predicting ground water contamination as a result of underground nuclear explosions in various types of geologic media. This will be done by investigating the solution and fixation of radioactive constituents in various geologic media and the movement of water through contaminated ground. The con-

tractor will appraise the ground water contamination problem at specific sites where underground nuclear tests are planned, either on the Nevada Test Site or at other continental locations, and recommend to the Nevada Operations Office the specific field work to be undertaken to gain the information needed to assure safe execution of the planned experiment or to acquire information which will assist in developing principles applicable to future experiments.

Effects predictions. Holmes & Narver, Inc., of Los Angeles, Calif., was during the year, assigned the additional task of conducting studies to develop guidelines to improve the prediction of effects of ground motions on surface and subsurface structures, both natural and man-made. These ground motions, as they are propagated from underground nuclear detonations, produce varying effects on structures at succeeding distances. In conducting pre-detonation surveys on and below the surface in an area surrounding a detonation site, predictions of effects may be greatly enhanced in accuracy when more is known about the responses of structures to ground motion phenomena.

Continuing studies. The Nevada Operations Office is continuing its arrangements with other Government agencies, including the U.S. Geological Survey, U.S. Weather Bureau, U.S. Bureau of Mines, U.S. Coast and Geodetic Survey, U.S. Public Health Service, and various laboratories and technical and support contractors in continuing special and long range studies in their respective fields.

Public Safety Aspects

The public safety program is concerned with effectively eliminating, or reducing to an acceptable minimum, any effects of tests or experiments which might harm people directly or indirectly, or damage public or private property or natural resources.

In the weapons, Vela Uniform, Plowshare, and reactor programs, the problems involved in the public safety program are principally embodied in the following general areas: (*a*) procedures must be established for preventing contamination hazards that can affect people either on or off the test site; (*b*) ground shock and its effects on both surface and subsurface structures either natural or man-made, must be considered; and (*c*) air blast, thermal radiation, and aspects of industrial safety must also be taken into account.

If safety criteria cannot be met in all of these problem areas, consideration will be given to postponement, cancellation, or change of

location or type of a planned test. For example, the Project Gnome experiment in 1961 under the Plowshare program, was delayed four hours until a wind shift occurred that would carry any possible release of radioactivity away from nearby populated areas. For additional information on the release of radioactivity from the Gnome event see Appendix 15.

Following each explosion involving a release of radioactivity into the environment of the Nevada Test Site, plans for monitoring levels of activity in the off-site area which extends out to a radius of about 300 miles are executed. The quantities of radioactivity in air, ground, water, milk, precipitation, and drinking water and exposures recorded by film badges distributed in the area are measured. (See Appendix 15 for data on environmental contamination from nuclear explosives).

Operational Safety Planning

While laboratory planning on experiments is underway, concurrent field operational evaluations by the Nevada Operations Office are performed. These evaluations determine the surface and subsurface geology of the region of interest. Geophysical information from existing data, or from additional seismic shock measurements, is obtained to ascertain the boundaries of a selected medium and the characteristics of the medium and the surrounding sediments.

Thermal radiation (with the danger of flash blindness and retinal burns) is an area in which substantial knowledge has been developed during past weapons testing and, as it is associated with atmospheric tests, is not a real problem during underground tests.

A comprehensive statement of the steps that are taken in these field evaluations can be found on pages 222–224 of the Commission's Annual Report to Congress for 1961.

Hazard Evaluation Work

Before conducting any experiment which may have adverse effects on the public or participants, a rather broad group of Commission contractors and Government agencies becomes involved in performing hazard evaluation and safety planning.

The laboratory or agency sponsoring the field experiment performs the first evaluation as part of its conceptual planning and continues to participate in evaluations and planning throughout the

operation. Other Government agencies, Commission contractors, and scientific and technical consultants are drawn into the evaluation and planning effort as required. Finally, a formal safety plan is developed by the Nevada Operations Office for each field event. When this formal plan is completed, it represents the concerted efforts of all interested Government agencies, Commission contractors, and technical consultants. It evaluates possible hazards for the benefit of the operational groups which perform the experiments and establishes criteria, rules, and guidelines for conducting the experiment within acceptable standards with respect to the health of people and to the safety of public and private property and natural resources.

RADIOISOTOPE DEVELOPMENT

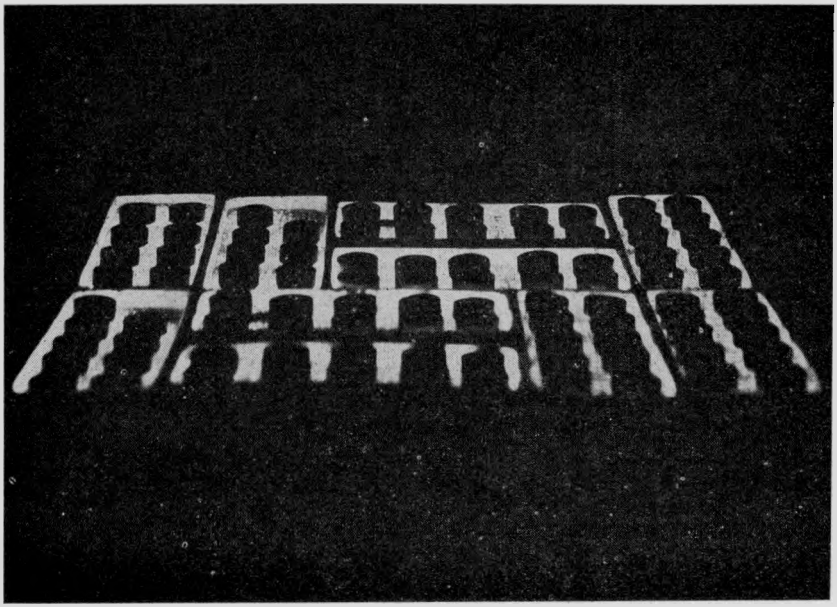
Under its Isotopes Development Program, the Commission sponsors exploratory studies required in the achievement of its long-range goal:

1. To advance radioisotope and radiation technology sufficiently to enable and encourage potential users to develop meaningful applications, particularly those to meet urgent public interest problems.
2. To accelerate the realization of the potential contribution of radioisotope and radiation applications to the national economy and welfare.
3. To make an important contribution to U.S. world leadership in the peaceful uses of atomic energy.

PRODUCTION AND MATERIALS

The Commission's isotopic production and materials activity assures the continuing availability of radioisotopes in adequate supply for programs of national interest. There are approximately 137 individual radioisotopes produced by the AEC. Many radioisotopes are further processed by private industry to the required form for end use and some radioisotopes are now being produced by private industry. New applications for radioisotopes are continuing to develop which requires increasing production, new radioisotopes, and additional product forms. Research and development is carried on in support of this production effort to provide new production procedures, improved processes, and improved products. Product evalua-

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Strontium 90 Titanate Pellets. The self-illuminated photo shows a portion of the 120,000 curies of strontium 90 titanate pellets that were installed in the SNAP–7D generator which will furnish electrical energy for the Navy's boat-type weather station. The photo was made at the Oak Ridge National Laboratory. This self-illumination results from the *Cerenkov* radiation due to the high intensity gamma rays impinging upon the alumina tray.

tion is performed to assess the nuclear, chemical, and physical properties of the radioisotope products for utilization and safety purposes.

Production and Sales

A growing interest in the use of strontium 90 and cesium 137 for isotopic power, process radiation, and medical teletherapy resulted in an overall increase in the production and sales of radioisotopes during 1962. As of November 30, a total of 515,637 curies had been shipped from Oak Ridge National Laboratory (ORNL) during 1962 as compared with 438,205 curies during the first 11 months of 1961 and 191,122 curies for the same period of 1960. Gross income from radioisotope sales also recorded a rise with 2.8 million dollars sold as of November 30, as compared with 2.7 million dollars in 1961 and 1.9 million dollars in 1960. As of November 30, 1962, ORNL has distributed a total of 2,080,864 curies in 169,052 shipments during the 16 year history of the radioisotope distribution program.

TABLE NO. 3.—RADIOISOTOPE SALES FROM OAK RIDGE NATIONAL LABORATORY

Type of Sales	Aug. 2, 1946–Dec. 31, 1961	Jan. 1–Nov. 30, 1962	Total to Nov. 30, 1962
Domestic	$14, 291, 157	$1, 350, 171	$15, 641, 328
Foreign	2, 053, 502	261, 265	2, 314, 767
Total commercial sales	16, 344, 659	1, 611, 436	17, 956, 095
Project transfers	2, 316, 292	200, 659	2, 516, 951
Medical subsidy [a]	3, 683, 549		3, 683, 549
Technical cooperation program, local sales to ORNL, Civilian defense	940, 794	79, 856	1, 020, 650
Special sales [b]	422, 091	919, 948	1, 342, 039
Subtotal	7, 362, 726	1, 200, 463	8, 563, 189
Total	$23, 707, 385	$2, 811, 899	$26, 519, 284

[a] Medical subsidy terminated June 30, 1961.
[b] Special sales category added July 1, 1961.

NOTE.—This table does not include sales by private commercial firms who act as secondary suppliers. other AEC facilities such as Mound Laboratory and Brookhaven National Labratory, private firms and universities who own reactors, nor imports into the United States from other countries.

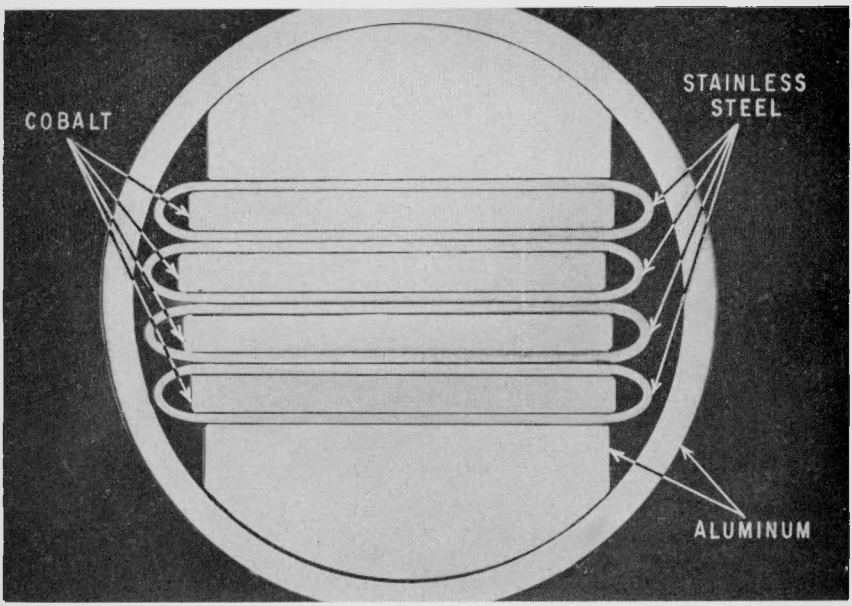
TABLE NO. 4.—RADIOISOTOPE DISTRIBUTION BY OAK RIDGE NATIONAL LABORATORY

[Includes project transfers, subsidy payments, etc.]

Radioisotopes	Aug. 2, 1946–Dec. 31, 1961		Jan. 1–Nov. 30, 1962		Total to Nov. 30, 1962	
	Activity (curies)	Shipments	Activity (curies)	Shipments	Activity (curies)	Shipments
Carbon 14	150	3, 782	29	201	179	3, 983
Cesium 137	182, 711	1, 745	120, 589	223	303, 300	1, 968
Cobalt 60	1, 058, 817	2, 344	64, 685	117	1, 123, 502	2, 461
Hydrogen 3	146, 093	1, 361	59, 037	202	205, 130	1, 563
Iodine 131	7, 305	48, 495	140	1, 634	7, 445	50, 129
Iridium 192	46, 905	982	5, 047	82	51, 952	1, 064
Krypton 85	14, 805	585	3, 928	148	18, 733	733
Phosphorus 32	1, 945	30, 624	97	1, 901	2, 042	32, 525
Promtheium 147	4, 594	490	2, 665	110	7, 259	600
Strontium 90	99, 246	971	256, 488	91	355, 734	1, 062
All others	2, 656	65, 697	2, 932	7, 267	5, 588	72, 964
Total	1, 565, 227	157, 076	515, 637	11, 976	2, 080, 864	169, 052

NOTE.—This table does not include several thousand curies of radioisotopes produced and distributed directly from other AEC facilities such as Mound Laboratory nor from reactors owned by private industrial firms and universities. Radiosotopes made in other countries and imported into United States are also not included.

Xenon 133 use increases. A significant increase in the quantities of xenon 133 produced and sold was evidenced during this past year; 2,455 curies were shipped during the first 11 months of 1962 as compared to 557 curies for a like period in 1961. This increase is attributable to the growing interest in the use of xenon 133 as a tracer in gas flow measurements. Sales to private users decreased for several radioisotopes, due to their availability from domestic and foreign suppliers. These radioisotopes included iodine 131, phosphorus 32, and iridium 192.



Food Irradiation Source. The Army Quartermaster Radiation Laboratory at Natick, Mass., will use the world's largest single cobalt 60 source—1,290,000 curies—in its studies on sterilization of foods by irradiation. The source, composed of more than 400 cobalt slugs, was produced at the Commission's Savannah River Plant. Drawing shows how the slugs were double-encapsulated in an inner, stainless steel "sandwich" and then in an outer, welded aluminum can.

Big sources. During this past year the world's largest single cobalt 60 source, 1,290,000 curies, was produced by Savannah River, for installation at the Army Quartermaster Radiation Laboratory in Natick, Mass. This facility is being used for research and development on processes for radiation sterilization of foods for use in military rations. This source is composed of slightly more than 400 cobalt slugs each double-encapsulated in an inner, welded, stainless steel sandwich and then in an outer, welded, aluminum can. These slugs were irradiated for several months in a Savannah River reactor to the desired specific activity.

In addition, a 100,000-curie source of cobalt 60 was produced at Savannah River for installation at the Bureau of Mines' Albany Metallurgy Research Center in Oregon. The source is being used in the investigation of radiation effects upon petroleum, coal, and metallurgical processes.

Radioisotope Production Development

As a result of improved separations and processing techniques, the fission products strontium 90 and cesium 137 became routinely available in megacurie quantities for the first time during the past year. Three million curies of strontium 90 fuels and over 1 million curies of cesium 137 fuels will be produced during fiscal year 1963 for use in such applications as isotopic power, process radiation, and medical teletherapy. The isotopes are being separated from high-level, aged wastes at the Commission's Hanford, Wash., plant and transported to Oak Ridge, Tenn., and Quehanna, Pa., for final processing.[6]

Advances both in reactor and cyclotron produced radioisotopes and in the development of improved radioactive sources have also been achieved. For example, a new technique for the preparation of sources for research application and civil defense instrument calibration was developed at Oak Ridge National Laboratory. It consists of absorbing radioactive material on an inorganic ion exchanger, Decalso, and then fusing the combination onto a ceramic backing. The sources are then coated with a thin layer of nickel. They are inexpensive to produce and are extremely safe.

Power sources. A wide variety of radioisotope fuels are being developed and produced to meet the needs for terrestrial, oceanographic, and aerospace auxiliary electrical power systems. Programmatic requirements now exist for varying forms of strontium 90, cesium 137, plutonium 238, and curium 242 as radioisotope heat-electrical power sources. Many hundreds of thousands of curies of radioisotope fuel were produced during the past year for auxiliary electrical power systems, or isotopic power units, now in use by the Weather Bureau, Coast Guard, and Navy in remote polar regions, on the ocean's surface, at great ocean depths, and in space.

The first cesium 137 power source was fabricated this year by ORNL. The 26,000-curie source is being used to provide power for an ocean floor seismograph unit developed by Royal Research, Inc., Hayward, Calif., in cooperation with Lamont Geological Laboratory of

[6] See pp. 178–179, 183–189, "Annual Report for 1961."

Columbia University. The cesium 137 is in the form of a borosilicate glass fused at very high temperatures. The source form has the desirable properties of high power density, chemical stability, and very low solubility in both fresh and sea water.

Space isotopic sources. Substantial progress is being made by ORNL in the development of a capability for producing up to 80 grams of curium 242 fuels annually. Produced up to the present in only fractional gram-to-gram quantities for research purposes, curium 242 has been selected as the isotopic fuel for auxiliary power in the Surveyor spacecraft because of its very high power density and easily shielded radiations. The Surveyor mission, designed to land instruments on the moon's surface in support of the Apollo program, will require tens of grams of the curium 242 fuel annually. It is anticipated that the first curium 242 fuel loading for an auxiliary power device will be produced during 1963.

The development of advanced fuel forms of plutonium 238 and polonium 210, intended primarily for use with aerospace auxiliary electrical power systems, is now in progress at Mound Laboratory. The higher operating temperatures afforded by these new fuel forms are necessary for the more efficient, lower weight isotopic power generators being planned.

Transuranic Isotope Production

Fuel elements fabricated from an alloy of aluminum and plutonium containing a small percentage of the plutonium isotopes are being irradiated in the Savannah River reactors to produce a high percentage of plutonium 242 for use as radiation targets for future transuranic element production in the High Flux Intensity Reactor now being constructed at Oak Ridge. Similar transplutonium elements were irradiated for use as the fuel in the Hanford Plutonium Recycle Test Reactor.

Analysis and Applications Branch

The Commission's Division of Isotopes Development has recently set up a new Analysis and Applications Branch to provide increased aid to industry and government agencies by establishing greater coordination between new developments and their translation into practical applications. A world-wide foreign literature survey of isotopes, abstracted by the Library of Congress, is now available on a

yearly subscription basis.[7] Quarterly technical reviews and a series of Executive Digests are planned to appraise technical and administrative personnel of new developments and potentially-useful applications of radioisotopes. Regional conferences will also be held but directed to specific industry areas, such as: electronics, wood, automotive, and chemical processes. An important new approach will be the design and use of "conspicuous demonstrations"—economic or commercial prototypes—of radioisotope techniques to more clearly point up to select industries the benefits of utilization. Finally, world developments in radioisotope and radiation technology will be critically reviewed with the objective of translating these into practical application for American technology.

Isotopes Development Center

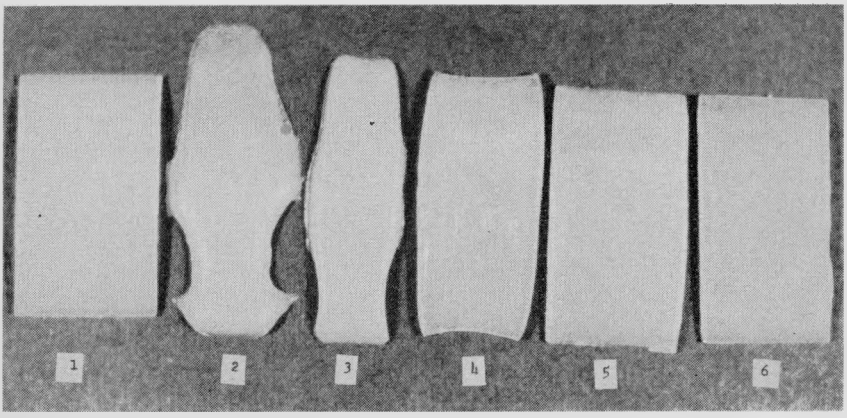
During the past year an Isotopes Development Center was established at Oak Ridge National Laboratory. This will serve as a center for advanced research on the development of production-process technology as well as for the development of new basic technology which will further the utilization of radioisotopes and nuclear techniques. The Isotopes Development Center includes highly unique facilities such as the Fission Products Development Laboratory, the Isotopes Technology Laboratory, the 86-inch cyclotron, plus electromagnetic separators used for separating highly enriched stable isotopes.

PROCESS RADIATION DEVELOPMENT

The Commission's Process Radiation Development Program has as its primary objective the fostering of technological developments leading to the productive use of large quantities of ionizing radiation. As a processing tool to create new materials or to improve current production processes, ionizing radiation represents a new source of

[7] One thousand abstracts on 3- by 5-inch cards will be made available each year at the annual subscription cost of $50. Subscribers will receive cards monthly. Orders for subscriptions should be addressed to Chief, Science and Technology Division, Library of Congress, Washington 25, D.C., and should be accompanied by check or money order made payable to Treasurer of the United States. Previous abstracts in this project have been compiled in report form in three volumes entitled *Radioisotopes in World Industry; Abstracts of Selected Foreign Literature.* These three volumes may be purchased under the numbers TID–6613, TID–6613 (Suppl. 1), and TID–6613 (Suppl. 2) from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for $2.50 each, or may be examined at AEC Depository Libraries as described in the journal, *Nuclear Science Abstracts.* Additional volumes of the current abstracts are planned at 6-month to 1-year intervals. These will also be available from the Office of Technical Services.

energy with great potential. Moreover, the fission products produced from the operation of nuclear reactors constitute a vast radiation energy resource thus providing AEC a special interest in fostering development of the use of isotopic radiation for processing purposes. Successful development of radiation processing would have the special advantage of converting fission products "waste" into materials having economic meaning. For the most part, the Commission's effort—which began in 1958—is not directed to specific product development. Rather, it is aimed at establishing the broad technology and principles of radiation application which can be gainfully employed commercially in developing specific radiation processes or products.

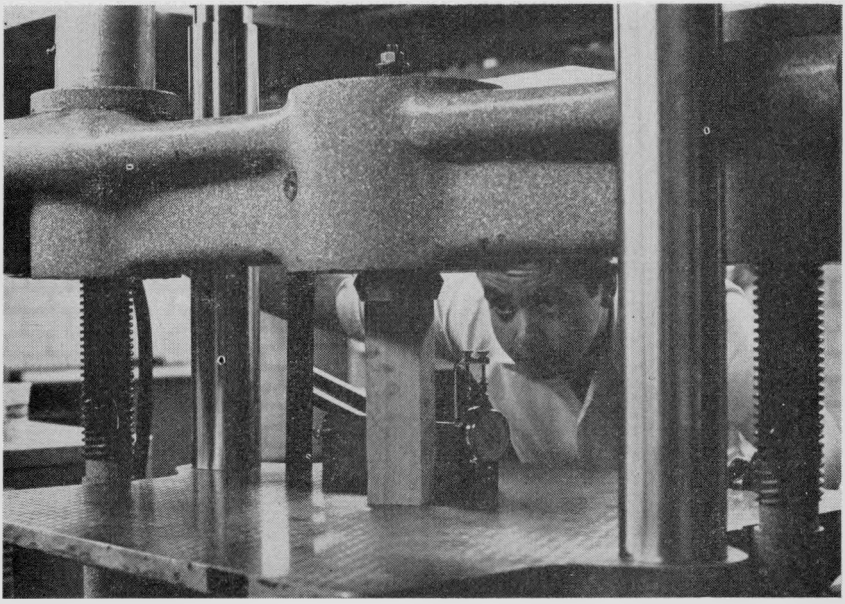


Heat Stability of Irradiated Plastic. Photo shows the heat resistance of cross-linked polyethylene, irradiated with 30 megarads (*#6*) and heated for five hours at 185° C., compared to the original unheated, unirradiated sample (*#1*) and compared to the similarly heated, unirradiated sample (*#2*). All samples except *#1* were heat-aged for five hours at 185°C. *#3* was irradiated with 1.2 megarads, *#4* with 10 megarads, *#5* was treated with 4 percent allyl methacrylate and irradiated with 1.2 megarads, and *#6* was irradiated with 30 megarads. Photo was made at Radiation Applications, Inc., Long Island City, N.Y.

The Process Radiation Development Program embodies research and development on engineering characteristics of megacurie radiation sources. The research program ranges from fundamental studies to empirical development and process demonstration with the research vectored toward ultimate practical application. The research program is conducted at various universities and industrial laboratories as well as at the AEC national laboratories.

Process Research

During 1962, the Commission had 22 contracts contributing to the development of process radiation techniques in addition to a program at Brookhaven National Laboratory. Research has continued on polymerization and graft polymerization systems. Basic studies devoted to the definition of reaction mechanisms have been carried out and several important advances made during the past year on the development of practical radiation polymerization systems. Crosslinked polyethylene, used for wire insulation in space vehicles, has been produced that requires less than one-tenth of the radiation previously needed to obtain the properties required. Present work indicates that polyisobutylene can be crosslinked; this has never before been achieved. This material has important applications within the rubber industry. The research is being conducted by Radiation Applications, Inc., Long Island City, N.Y., under AEC contract, who will employ the technique to examine the possibility of effectively crosslinking or curing cellulose—a long sought goal.



Wood-Plastic Alloys. New woods, with improved properties, have been made by impregnating them with monomers, and subjecting them to massive ionizing radiation from cesium 137 or cobalt 60. Samples have been made at West Virginia University which exhibit up to 300 percent increase in hardness, and 80 percent decrease in water absorption. The photo shows the compression testing of a block of pine wood which had been previously treated with methyl methacrylate and irradiated. Such wood has demonstrated an ability to withstand more than twice the pressure before splintering as against the untreated wood.

Wood "alloy". Significant strides have been made by West Virginia University during the past year on the development of radiation produced wood-plastic "alloys"—wood plastic material—by impregnating various woods with chemical monomers under pressure and subjecting them to ionizing radiation. The beauty and utility of the original wood are maintained while its basic properties are greatly enhanced. Samples of maple and pine have been produced that exhibit a 300 percent increase in hardness, an 80 percent decrease in water absorption, a 50 percent to 75 percent increase in dimensional stability and an increase in the elastic limit by a factor of two. This material could greatly improve the scratch resistance of furniture, upgrade soft woods for hardwood use, improve weather resistance and contribute greatly to the utilization of wood for a countless number of other applications. Present research is devoted to a study of maple, redwood, pine and oak with suitable chemical monomers. Future research will concentrate on other species of wood and also investigate some of the fundamental reactions involved in the process.

Colloidal systems. Studies have been initiated of the effects of ionizing radiation on a wide range of colloidal systems. The systems presently under investigation are aerosols, foams, emulsions, lyophilic and lyophobic sols and suspensions. The information resulting from this study being done by the Georgia Institute of Technology will be useful in a number of industrial activities such as chemical processing, mixing, and emulsion reactions.

Textile improvements. Further research effort was made on the use of radiation in the textile industry. During the past year there have been several technical advances with the result that it is now possible to modify cotton by the addition of acrylonitrile, producing an almost completely microorganism-resistant material. This work was done by North Carolina State College. The material retains the appearance and feel of untreated cotton. Several systems developed from this research are now approaching commercial feasibility.

Krypton use. Research has continued on many new applications of krypton 85 as a gaseous source for radiation processing. Studies have been conducted by Air Reduction Co., Murray Hill, N.J., on gas phase polymerization, graft polymerization, a novel self-luminous lamp, and a theoretical evaluation of a nuclear-radiation-pumped optical maser.

Chemical reactions. In addition to the research aimed towards the development of specific techniques, effort was also expanded on the study of the mechanisms and kinetics of fundamental radiation-

induced chemical reactions. Information obtained from such research has a direct bearing on the optimization of all radiation processing systems. For example, during 1962 the William H. Johnston Laboratory, Baltimore, Md., have discovered and confirmed a new mechanism for hydrazine synthesis as well as increasing the G-value—the radiation-related efficiency of conversion.

Radiation Engineering

Completed in 1962 as the largest facility of its type in the world, the High Intensity Radiation Development Laboratory (HIRDL) at Brookhaven National Laboratory, is being used to: (*a*) obtain engineering data on a variety of radiation sources in the multi-megacurie range, this information is essential for the design of future irradiation facilities for use in a wide variety of applications of radiation energy; (*b*) in the development of more efficient techniques for the handling of large scale radiation sources; and (*c*) in training scientists and engineers in the uses of such radiation sources for research purposes and industrial applications.

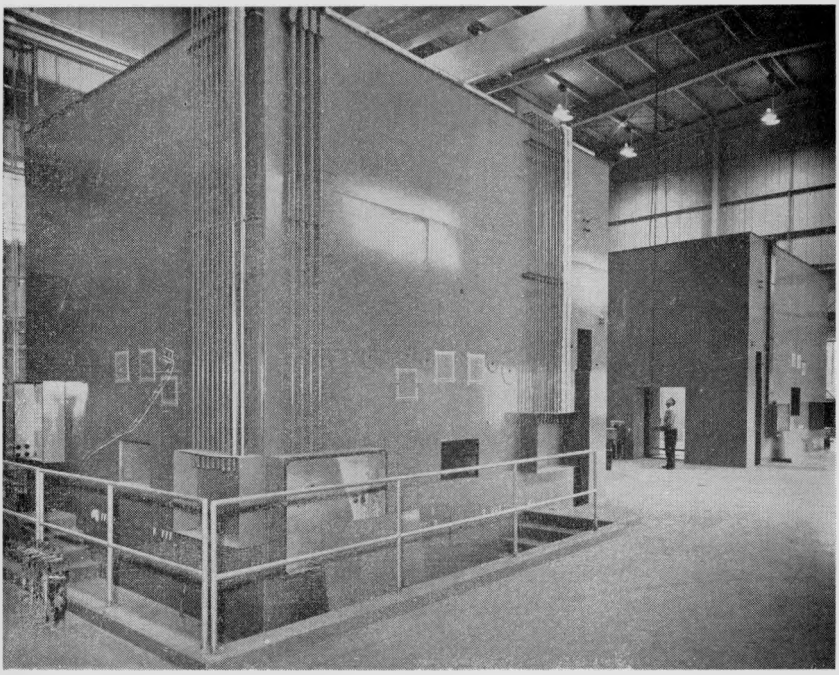
The total level of radiation expected to be employed in this laboratory is approximately 3 million curies. Most of the sources will be of cobalt 60 and cesium 137; spent reactor fuel elements will also be used as sources of radiation.

The main design features of the HIRDL are two unique cells, one an irradation cell for the experimental work with radiation sources, and the other a work preparation cell in which various types of sources will be prepared for experimental use.

The Commission has designated the facilities at Brookhaven as a Radiation Development Center. It is intended that the center will provide a focal point for radiation research and development in the United States.

Dosimetry System

During 1962, research on high level dosimetry systems was expanded to meet the increasingly greater need for the development of high level radiation dosimetric techniques engendered by the increased use of gamma irradiation facilities of the kilo- and megacurie ranges in both commercial and research applications. Heretofore the Fricke dosimeter and the Thimble ionization chamber have been accepted generally as standard methods of measuring integrated dose and dose rate respectively in the intermediate dose range. These two methods, however, have been found to be inadequate for use at the high levels en-



HIRDL Completed. The new High Intensity Radiation Development Laboratory (HIRDL) at Brookhaven National Laboratory was completed during the latter part of 1962. The laboratory is equipped to handle radiation sources totaling approximately two million curies. HIRDL is a part of the Commission's Radiation Development Center which has been organized to coordinate all research and development activities related to the use of radiation as a processing tool. Photo shows the two major cells in HIRDL. The "preparation" cell in the foreground is used to prepare the special high intensity radiation sources; the "experimental" cell (*right*) is used for the irradiation of various materials as a part of the process radiation development program. A 45-foot long canal (not visible in photo), 16 feet deep, and with a 20-foot deep storage pit in the center, connects the two cells.

countered in present day facilities; the Fricke dosimeter has a limited range (up to 4×10^4 rads), and the Thimble ionization chamber is seriously damaged by radiation levels above 3×10^5 rads/hr. As a result, research at Brookhaven National Laboratory has been directed toward extending the range of the standard Fricke integrating dosimeter and toward developing a new high level dose dosimeter—the Silicon Solar Cell dosimeter.

The range of the Fricke dosimeter has been extended from 40,000 (4×10^4) rads to beyond a million (10^6) rads. The result of this research is a new standard high level dosimetry system which is reliable and accurate and not basically different from the original, well tested, Fricke dosimeter.

The new Silicon Solar Cell dosimeter, which was developed at Brookhaven National Laboratory in cooperation with Bell Telephone Laboratories, is an accurate, reliable dose-rate dosimeter with a continuous linear range from 10^4 to 10^7 rads/hr. It is simple and easy to use, requiring only a milliammeter as associated equipment and is not seriously damaged in high level radiation fields.

Work has also been initiated at the Atlantic Research Nuclear Corp., Alexandria, Va., on a completely new dosimetry system utilizing the effects of radiation on organic-metallic bonding in chemical systems.

ISOTOPE TECHNOLOGY DEVELOPMENT

In this part of the Isotopes Development Program, specific attention is being given on three major fronts.

The first of these is development of new principles for use of radioisotopes and nuclear techniques. In the second, possible applications in the public interest are taken through engineering development of a prototype device or procedure. Successes have been achieved in such diverse areas as determining the geographical origin of opium, measuring fluid flow in a closed system without internal sensors, identification of individuals by their type and quantities of minor elements, assuring pesticide removal from foods, and measuring moisture at very great altitudes.

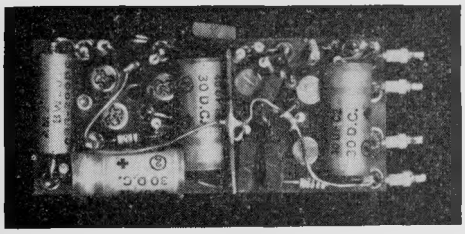
In the third major activity, criteria for safety testing of radioisotopes sources and devices are being developed. This information will assist regulatory agencies in establishing safe yet reasonable regulatory standards and the manufacturer in designing more reliable equipment. Most important, the public will be assured that isotope equipment is built to meet carefully developed safety criteria.

In carrying out these important phases of isotope technology development, specific attention is also being given to possible industrial use as a dividend from these activities. Industrial organizations have been alert to these possibilities and, in several cases, have expended their own funds to adapt the new principles and techniques developed under this program to meet their own particular needs.

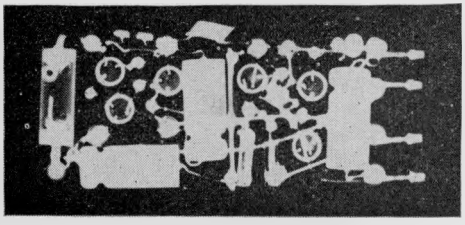
Non-Destructive Testing

High energy isotopic gamma rays have been put to use in many industrial and scientific applications, however, no low-energy photon (X-rays) emitting radioisotopes are available with half-lives long enough to bring the advantages of isotopes sources to critical absorptiometry, fluorescent excitation, and medical X-ray technology.

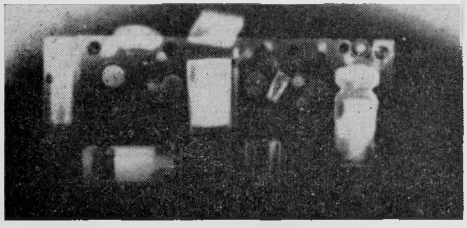
Optimization of secondary X-rays from long lived beta emitting isotopes has largely alleviated this limitation. Two prototype sources of promethium 146 and krypton 85 with optimum output peaking at specific energies have been designed, constructed and demonstrated in each of the application areas mentioned.



Circuit board photograph



X-ray radiograph



Neutron radiograph

Neutron Radiography. The above is a comparison of the type of detail seen of the same electronic circuit board through three different means of examination: normal photography, X-ray radiography and neutron radiography. The latter is a new examination technique developed by the Armour Research Foundation, Chicago, Ill., and shows promise of being superior in certain industrial applications such as turbine blade examination, electronic component inspection, and brazed-joint examination.

The technical feasibility of using neutron fluxes to examine thickness or the possibility of voids in certain materials, such as graphite, to density. The neutron radiography shown in the photograph illustrates the relative details as opposed to X-ray and is indicative of the discrimination not possible with X- and gamma-rays; both X- and gamma-rays have absorption coefficients approximately proportional X- or gamma-rays. In addition, the random variation in neutron appears to offer considerable advantages over comparable fluxes from cross sections from element to element will permit many instances of advantages of this technique. The potentialities of neutron radiography coupled with techniques for remote imaging by electronic means also is being investigated.

Tritium Labeling

An important new technique has been successfully developed under contract with the Consolidation Coal Co., Library, Pa., for labeling organic compounds with tritium. This method utilizes a radioactive acid catalyzer and has the advantage of being rapid, simple to use, and can be carried out in a test tube. Many high molecular weight organic compounds such as P-nitrotoluene and P-cresol have been prepared that previously have never been satisfactorily labeled.

Computer-Coupled Activation Analysis

Widespread application of activation analysis to situations involving large numbers of samples has been limited by the complicated data interpretation involved and specialized skills required. Consequently the unusual analytical sensitivity of this nuclear technique has not been available for use in analysis of large numbers of samples as required for pesticides in food and biological tissues.

Over the past 3 years, the techniques of computer-coupled activation analysis have been worked out by Texas A. & M. College to overcome this problem and a program is now under way in cooperation with the U.S. Department of Agriculture to demonstrate the practicality of this technique for automatically identifying and measuring toxic residues in food product samples. The principle of the technique is the identification of chemical elements by computer analysis of the gamma ray spectrum of the sample and automatic comparison of this spectrum with recorded spectra in an isotopic library.

Clathrates and Kryptonates

Portable monitors for measuring sulfur dioxide, ozone, and fluorine pollution in air have been developed at Tracerlab, Inc., Waltham,

Mass., utilizing the unique clathrate krypton-release principle. The released krypton 85 is measured by a *Geiger-Mueller* tube and the activity is related to the concentration of gaseous pollutant. The major progress in this area during the past year has been the findings of new materials to physically contain the gaseous krypton 85.

It has been determined by Parametrics, Inc., Waltham, Mass., that krypton will diffuse into most materials when placed in contact with it under conditions of high pressure and temperature. Krypton diffusion has proved effective for all 40 of the elements and compounds tested to date. Many of the metals have been found to retain krypton gas with little or no leakage. This new family of "kryptonates" release the radioactive gas when reacted chemically as do the clathrates. With such a wide variety of host materials available for the radioactive krypton it now appears possible to use the krypton release technique as a highly sensitive and specific indicator for a great variety of chemical reactions.

Water Resources Research

Ground water hydrology has never been fully understood due to the many complex factors, such as the nature of the soil, water-flow gradient, porosity, and particle size. A better understanding of these parameters will throw light upon the distribution of subsoil water, upon the discharge of manmade wastes, and will result in achieving better water supplies, particularly along the salt-intruded coastal land areas. Test models of soils have demonstrated for the first time how water plus added tracers flows under these complex conditions, and new concepts derived for interpreting flow patterns. This development was achieved by the U.S. Geological Survey under Commission contract, and the technology has been applied by the Survey in researching water problems in Pakistan and Mexico in cooperation with international organizations.

The accuracy of water power turbine rating is important since this relates to the true measure of the water resources of an area and available electrical energy. A new and improved turbine rating technique, developed under a joint program of the AEC and the U.S. Geological Survey, has resulted in an increase in measurement accuracy through the use of the gold 198 radioisotope, along with a big saving in the time required for determination. Experimental work was carried out at the Ocoee Dam No. 3 and the Dale Hollow Dam, both in Tennessee.

Aerospace Applications

Work is continuing with other Government agencies to develop the potential of radioisotopes in meeting aerospace analytical problems. An upper-atmosphere density-sensing device, developed by Parametrics, Inc., for the Commission's program in conjunction with the Weather Bureau, is now being tested by the Air Force for application as an altitude sensing system in advanced space planes and re-entry vehicles. The gauge measures the attenuation of soft X-rays by the thin upper atmosphere. The krytonate gaseous release technique described above and an argon-nitrogen ratio analyzer developed by Parametrics for upper atmosphere use are being adopted by NASA for anaylsis of the atmosphere of Mars. Investigation of the computer-coupled activation analysis techniques for analyzing the surface of the moon is being carried out at Texas A&M College under a joint AEC–NASA program.

Crime Detection

A new and very promising area of use for activation analysis is in forensic science. Analysis of minute objects of evidence or characterization of larger items through their trace constituents requires the extreme sensitivity available in this method. It has been demonstrated that trace constituents of human hair can be used to identify an individual. Work is under way at the Oak Ridge National Laboratory to define the applicability of this technique. It has also been demonstrated that activation analysis of the minute explosion residue wiped from a suspect's hand can determine, with a sensitivity higher than that of any known method, if he has recently fired a gun. General Atomics, San Diego, Calif., who has been conducting this work, has found that in some cases it is also possible to determine the type of cartridge used. Oak Ridge National Laboratory results also have proved that other crime objects such as paints or glass can be compared and matched by this method.

Air Pollution and Meteorological Problems

Measurement of the chemical and physical characteristics of the upper atmosphere is becoming increasingly important. An improved clathrate krypton release system by Parametrics, Inc., has yielded information on the relative concentrations of ozone and monatomic oxygen in the upper atmosphere. Their laboratory tests have proved the feasibility of an isotopic X-ray absorption system for determining the argon-nitrogen ratio in the upper atmosphere and a device is

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under construction. Through test flights the Office of Naval Research, the Weather Bureau, and the U.S. Air Force are evaluating these devices for their purposes.

Food Purity

Increased effort has been directed towards improving safeguards relative to measuring residual insecticides on foodstuffs. An isotope method has been successfully applied to this important area for the first time and has proven to be the most sensitive and rapid technique for measuring such insecticides as DDT, Deldrin, and related compounds. The method, developed by Nuclear Science and Engineering Co., Pittsburgh, Pa., makes use of a double isotope dilution technique.

Applications of Direct Interest to AEC

Many of the radioisotope applications being developed, either under Commission contracts or by industry on its own, are of direct programmatic benefit to the AEC. As an outgrowth of the joint development by the Armour Research Foundation, Chicago, and the Badger Meter Co., Milwaukee, Wis., of a meter employing a new mass flow principle, nuclear reactor operators are considering the application of such a meter for measuring the flow of liquid coolants and moderators in reactors. An isotopic X-ray device has been successfully demonstrated by Tracerlab, Inc., for non-destructively analyzing reactor fuel elements. The device measures the uranium content in the element by sensing the number of X-rays which are scattered without loss of energy (*Rayleigh* Scatter).

Periodic coal pile inventory is necessary at AEC production sites such as Portsmouth, Ohio. Routine inventory procedures require several weeks, much expensive equipment, and many man-hours. Measurement accuracy is poor, and even a 1–2 percent error can result in considerable overcharges. To improve determinations of inventory, a radioisotope density-moisture gage has been developed by the Laboratory for Applied Science at the University of Chicago that appreciably decreases the measurement time and improves the accuracy. Many other Commission laboratories and AEC contractors benefit from such newly developed isotope techniques.

Safety Testing

The development of technical criteria as a basis for safety testing is important to both the AEC and manufacturers of radioisotope

sources and devices. Accordingly, the AEC has established a research and development program to develop technical information needed to determine such criteria. In developing this criteria, emphasis is being placed upon: (*a*) the development of tests for chemical forms of radioisotopes used as sealed sources to assure that they are biologically inert, yet efficient in performing their intended purposes; (*b*) the development of tests for sealed radiation sources that will assure optimum structural strength to eliminate the possibility of inadvertent release of radioactive material; and (*c*) development of tests to establish safe mechanisms for preventing exposure accidents with such devices as radioisotope gauges, radiography equipment, and teletherapy units.

Tests are being developed to evaluate vibration and impact stability, temperature stability, corrosion resistance to chemical fumes, liquids, etc., and radiation stability of sealed sources. This research and development work is being performed at both Commission and private research laboratories, such as Battelle Memorial Institute, Columbus, Ohio; the Underwriters Laboratory, Chicago; and Oak Ridge National Laboratory.

The results of this research and development program are intended for use in developing safety standards for adoption by: industrial standards associations, manufacturers of radioisotope sources and devices, and by regulatory agencies responsible for the safe use of radioactive materials.

RADIATION PASTEURIZATION OF FOOD

The objective of the Commission program on radiation pasteurization of foods is to develop the technology necessary for demonstrating the technical and practical feasibility of using relatively low doses of radiation to extend the refrigerated shelf life of selected perishable foods. Extension of this technology to specific commercial applications would be carried out independently by private industry.

Program Progressing

Meaningful and encouraging research results obtained thus far in the Commission's 5-year research and development program indicate that radiation is effective for preserving foods in the manner envisioned. Notably, process parameters of radiation pasteurization have been established at the laboratory level for several of the foods under investigation, including particularly strawberries, peaches, haddock, and clams. Extensions of shelf life of several days to several

weeks have been realized, with virtually no loss of nutritive value due to the radiation process. A determination of market feasibility and economics of fruit preservation by radiation pasteurization is well under way. A protocol to obtain clearance of packaging materials has been developed. Initial results are now available concerning the wholesomeness, microbiological and nutritional aspects of radiation-pasteurized food.

The National Fisheries Institute has created an industry Committee on Low Dose Preservation of Sea Foods to monitor results of research. Through this and similar media, industry is being kept well abreast of progress.

The first general public display of low-dose radiation-pasteurized food was made by the Commission at the Fifth International Food Congress and Exhibition in New York City during September. The items displayed were fish and fruit products—crab, shrimp, flounder, strawberries, grapes, lemons, and nectarines.

Process Parameters

Inasmuch as the majority of research contracts originated to date are of two or more years duration, much of the work as outlined in the 1961 Annual Report is still in progress.

A continuing program of research and development on fruits and vegetables is being conducted at the University of California's Davis campus. The work has demonstrated, among other things, the delayed ripening effect in fruits through the control of respiration rates which, in turn, is dependent on the radiation time, rate, and dose. The University has recommended specific radiation process procedures and techniques for several items. It has also made the significant finding that vitamin C destruction in strawberries is far less than originally believed.

Clams and haddock are being investigated through coordinated efforts at Massachusetts Institute of Technology and the U.S. Department of Interior's Technological Laboratory at Gloucester, Mass. Both products have responded well to radiation at doses considerably lower than anticipated, and both have been rated well by expert taste panels formed by the above laboratories.

The program on shrimp started at Louisiana State University in early 1962, and results are quite favorable. Required radiation doses are, as with clams and haddock, far below early estimates.

Paralleling the work on the east coast, a coordinated effort is in progress at the University of Washington and USDI Technological Laboratory, both in Seattle, to develop Pacific crab and flounder into acceptable radiation processed items. While meaningful results are

just beginning to be forthcoming from the research, these products also appear to be quite amenable to radiation pasteurization.

Economic Analysis

A market feasibility and economic analysis of radiation-pasteurized fruits, compared to conventional marketing techniques, is currently being conducted for the Commission by the Marketing Economics Branch of the U.S. Department of Agriculture. Results thus far indicate a strong interest in the proposed process by various segments of industry, and a general belief that the product will be economically competitive.

Irradiators

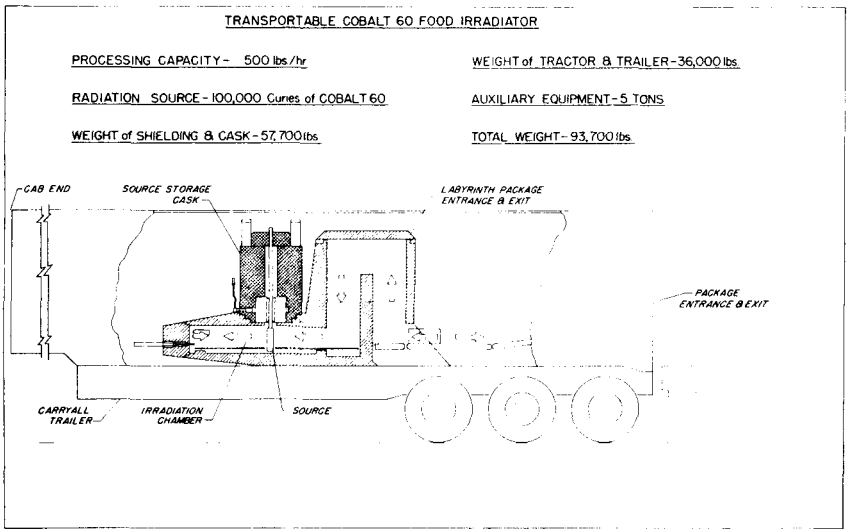
Conceptual design studies of two transportable food irradiators—one utilizing cobalt 60 and the other an electron machine source—were completed by Associated Nucleonics and Hughes Aircraft for Brookhaven National Laboratory. These irradiators are designed for large scale acceptability, storage, and shipping tests. They will enable a wide scale demonstration of the feasibility of low dose radiation processing and afford an opportunity to develop economic data on process costs. Final plans for actual construction of these units have not yet been developed.

Early in 1964, design and construction will be initiated on a Marine Products Development Irradiator. This irradiator, utilizing 300,000 curies of cobalt 60, is designed for large scale testing of radiation pasteurization technology and will be located at a fishery port yet to be selected.

Wholesomeness

With firm guidelines established in the determination of radiation parameters, expansion of the biomedical research phase of the program has begun. Nutritional and microbiological aspects related to wholesomeness and safety are receiving continual emphasis. Nutritionally, vitamin C and protein are the most important nutrients in fruits and fish, respectively. In the former case, vitamin C loss has been found to be minimal in certain fruits, while protein or amino acid destruction is undetectable in clams and haddock. This effect on other products is scheduled for investigation.

Studies on pathogenic microorganisms are receiving continuing emphasis. Major strides have been taken in the development of a



Transportable Irradiator. This Brookhaven National Laboratory conceptual drawing depicts the current concept of a transportable irradiation unit, designed to support the Commission's radiation pasteurization of food program. It would be fueled with approximately 100,000 curies of cobalt 60. With a semiproduction capacity, the unit will be capable of demonstrating the practical feasibility of radiation pasteurization as well as aiding in the determination of the economics involved.

protocol, in cooperation with the U.S. Food and Drug Administration, which, when completed successfully, should establish the basis for clearance of fruit and fish products.

A protocol has also been developed by the Continental Can Co., in coordination with the U.S. Food and Drug Administration, related to the clearance of packaging materials. Emphasis is on the study of extractables—chemicals produced in the packaging material that are susceptible to absorption by the contained food—from the packaging material in contact with the food product during radiation processing. Specific studies in this area were begun in late 1962.

Future Plans

In March 1962, the Joint Committee on Atomic Energy, Subcommittee on Research and Development, held hearings to determine the status of the Nation's coordinated Food Irradiation Program. The Army outlined the status of its high dose radiation sterilization program while the AEC reviewed its efforts on radiation pasteurization of foods. The Commission plans to continue its research and development program over the next several years within the limits of available funds.

Quartermaster Radiation Laboratory

The AEC agreement with the U.S. Army's Quartermaster Corps to design, construct, and test operate a radiation facility at Natick, Mass., to support radiation sterilization of foods was brought to a successful completion when the laboratory was formally turned over to the Army in October.

Approximately $1.8 million was allotted by the Army for the laboratory, which contains a radiation process area, a complete food preparation area, and supporting administrative and laboratory facilities. The radiation sources are, in themselves, unique. The cobalt 60 source, at 1.29 million curies of activity, is the world's largest source of its type. A powerful linear accelerator, fabricated by Varian Associates, Palo Alto, Calif., and rated at 24 Mev, 18 kw, complements the cobalt 60 source.

A highly significant aspect of this 2-year project was the cooperation and coordination which was developed and continued throughout between the AEC and the Army. This excellent relationship was essential to the timely completion achieved, and the inclusion of the desired features into the finished laboratory. The Army, further, has offered use of the laboratory to the Commission in conjunction with its radiation pasteurization of foods program.

STABLE ISOTOPE DEVELOPMENT

Since July 1, 1960, Monsanto Research Corp., contractor-operator of the AEC's Mound Laboratory, has had the responsibility for the purification, sales, and distribution of the stable isotope helium 3 throughout the free world. During 1962, 1,035 liters of helium 3, valued at $155,000, were shipped to research laboratories and educational institutions throughout the world.

The increased interest in the properties of materials at very low temperatures (below the freezing point of air) has created the need for accurate techniques to measure temperatures near absolute zero (459.72° F.). Monsanto Research Corp. at Mound Laboratory, in cooperation with Los Alamos Scientific Laboratory and the National Bureau of Standards, is attempting to establish helium 3 as an international temperature scale at these very cold temperatures. Scientists at Los Alamos Scientific Laboratory have shown there is a direct relationship between the vapor pressure of helium 3 and temperature from 0.3 to 3.2° Kelvin (from 459.36° F. to −453.1° F.). The helium 3 will be purified and distributed from Mound Laboratory.

INTERNATIONAL ACTIVITIES

The Commission's program for international cooperation in the peaceful applications of atomic energy is carried out largely through agreements with the International Atomic Energy Agency (IAEA) and the European Atomic Energy Community (Euratom) and through 36 agreements for cooperation with individual countries and West Berlin.

The Commission's international activities are aimed both at helping cooperating nations develop their peaceful atomic energy programs, and at supporting the U.S. atomic energy program. Training programs for foreign students, library grants, and furnishing technical advisors to other countries are examples of AEC activities which assist other nations in their own atomic energy development.

Information exchange programs such as that with the United Kingdom on the Dragon gas cooled reactor project, and with Canada on the heavy water moderated reactor program illustrate cooperative efforts with other countries which will be of direct benefit to U.S. reactor programs. Activities such as these eliminate the need for the Government and U.S. industry to duplicate research and development work that is carried out abroad.

Another major activity under the international program is the distribution abroad of special nuclear and other materials. The sale and lease of this material not only benefits the recipient countries by furthering their peaceful atomic energy programs but is also returning increasingly substantial revenue to the AEC with the expansion of nuclear power developments abroad.

The Commission's international activities as administered by its Division of International Affairs during 1962 are summarized below.

POWER REACTOR PROGRAMS

U.S. Euratom Reactor Program

Power reactors to be constructed under the joint U.S.-Euratom reactor program increased from a single approved project in 1961 to a total of two approved projects by the end of 1962 with a third project in the final stages of consideration. Under an invitation issued September 21, 1961, for power reactor projects to be completed by December 31, 1965, a proposal from a Franco-Belgian group was approved for participation in the joint program.

This proposal was from the Societe d'Energie Nucleaire des Ardennes (SENA) for the construction of a 210,000 electrical kilowatt (ekw) pressurized water reactor near Givet, France. A group of seven French companies (FRAMATOME), three Belgian firms, and the

Westinghouse Electric International Co. will supply the plant equipment.

The German firm KRB (Kernkraftwerk—RWE-Bayernwerk), formerly designated as RWE, submitted a proposal for a General Electric-designed 237,000 ekw boiling water reactor to be built near Gunzburg on the upper Danube River which was under final consideration by the United States and Euratom Commissions at the end of the year.

A proposal from the Italian SELNI project, the pressurized water reactor now under construction on the Ligurian Riviera between Genoa and La Spezia, was judged not eligible for consideration under the second round U.S.-Euratom power reactor invitation.

The 150,000 ekw boiling water reactor being built near Punta Fiume, Italy, by the Societa Elettronucleare Nazionale (SENN) is scheduled for completion in 1963. It is being constructed under the 1959 U.S.-Euratom joint invitation.

Under the terms of the joint program, incentives available to projects for participation include a 10-year fuel element guarantee, long term capital loans to cover part of the plant construction costs, supply of fuel inventory on a deferred-payment or lease basis and a market for 10 years for plutonium recovered from the reactors.

Joint Research and Development Program

With the acceptance of the SENA pressurized water reactor proposal under the second round U.S.-Euratom power reactor invitation, the Joint Research and Development Board expanded the scope of its program to include projects relating to pressurized water reactors as well as boiling water types. The objectives of the research and development program are the improvement of the performance of the types of reactors to be constructed under the joint U.S.-Euratom nuclear power program and the lowering of fuel cycle costs.

As of November 15, 1962, U.S. financed research and development contracts approved by the Joint Board totaled 34 projects costing $9.57 million. Over 60 projects costing approximately $15 million were being supported by Euratom.

20-year Fuel Supply Contract for SENN Reactor

Under provisions of its first long-term fuel sales contract, signed this year with Euratom, the AEC will sell enriched uranium fuel valued at $29,300,000 at current prices over the next 20 years to supply the SENN power reactor project in Italy. The contract provides for sale to Euratom on a deferred payment plan of a net amount up to 4,000 kilograms of contained uranium 235.

A separate purchase contract provides that the United States guarantees, under stated limitations, to purchase plutonium and uranium 233 produced in the SENN reactor. The United States will give Euratom credit for the enriched uranium recovered from the materials sold to Euratom when that enriched uranium is returned to the United States.

Cooperation in Fast Reactor Development

The Commission, in December 1962, approved a program of cooperation with Euratom in the development of fast reactors, under which the AEC, subject to Congressional and Presidential authorization, would supply Euratom between 400 and 500 kilograms of plutonium. The material would be used in the second core of the French *Rapsodie* fast reactor, and in fast critical assemblies located at Karlsruhe, West Germany, and Cadarache, France.

Indian Power Reactor

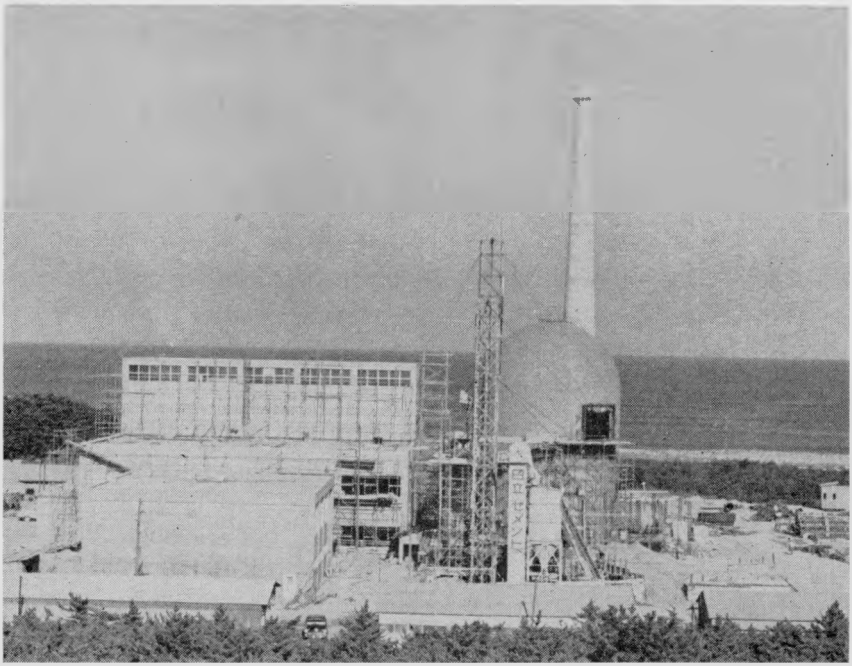
The Government of India's Department of Atomic Energy has provided an American firm, International General Electric, with a Letter of Intent for the design, manufacture, construction, and initial operation of the Tarapur Atomic Power Station, which is to consist of two 190,000 ekw boiling water reactors and will cost approximately $100 million. The Tarapur Station, which will be located approximately 60 miles north of Bombay, will provide about 20 percent of the base load electrical energy for two major grid centers serving the area.

Supply of enriched uranium, financing arrangement and safeguards, including the role the International Atomic Energy Agency might play in their application, are under discussion between the United States and Indian Governments. Appropriate safeguards are required on any enriched uranium or other special nuclear materials and equipment that are transferred abroad, to ensure that the material and equipment are used only for peaceful purposes.

Japanese Power Reactor

The 12,500 ekw Japan Power Demonstration Reactor (JPDR) which is being built by General Electric Co. of Japan, at the Tokaimura site, 70 miles northwest of Tokyo, for the Japan Atomic Energy Research Institute is about 80 percent complete.

The JPDR pressure vessel which was designed by General Electric and was fabricated by the Hitachi Co., Ltd., in Japan has been installed. Fuel testing is complete and installation of the turbine-



First in Asia. With criticality scheduled in March 1963, the 12,500 electrical kilowatt Japan Power Demonstration Reactor will be the first known nuclear power facility in Asia. The Japanese Government-owned plant is at Tokai-mura, about 70 miles northwest of Tokyo. The boiling water reactor was fabricated in the United States by the General Electric Co.

generator began during November. Criticality is now scheduled for March 1963. The JPDR will be the first operable power reactor in Asia.

Belgian Power Reactor

The BR–3, an 11,500 ekw pressurized water reactor at Mol, Belgium, achieved criticality on August 29, 1962. This is Belgium's first power reactor and was designed in part by the Westinghouse Corp.

U.S. PARTICIPATION IN IAEA ACTIVITIES

Smyth Committee Report on U.S. Policy Toward the IAEA

During the early months of 1962, the U.S. Department of State convened an Advisory Committee to review the policy of the United States toward the International Atomic Energy Agency. The Committee consisted of eight prominent persons from government and

business under the chairmanship of Ambassador Henry D. Smyth, U.S. Representative to the IAEA.

In its report, the Committee reaffirmed the U.S. policy of strong support for the IAEA, on the grounds that the peaceful uses of atomic energy can and should play an important role in our foreign policy and that support of the IAEA is an effective means for the furtherance of this policy. In a statement to the Congressional Joint Committee on Atomic Energy, the AEC agreed with these conclusions and also agreed that the IAEA had, in its first 4 years, served a useful function and contributed significantly to the basic goal of promoting the peaceful uses of atomic energy.

The recommendations in the report cover the entire range of the IAEA's activities, but the report identifies the development of nuclear power and of safeguards against the diversion of material and equipment to military purposes as the areas in which the Agency can make the greatest impact in the future. The United States has continued during 1962 to emphasize these areas of IAEA activity, to provide experts, equipment and fellowships for Agency programs, and to take a leading part in scientific conferences and symposia sponsored by the Agency.

Sixth General Conference

The Sixth General Conference of the IAEA was held in Vienna from September 18 through 26, 1962. Seventy-two member states participated, and observers were present from a number of other states as well as from the United Nations and various other international bodies.

The Conference was characterized by the absence of significant disputes on items of major importance. Among the actions taken by the Conference were: approval of the 1963 Program and Budget amounting to $9,562,100 and resolutions under which the Agency will continue, and in some cases expand, its efforts in the field of nuclear power; its development of a long-term plan; its study of ways and means of establishing an international center for research in theoretical physics; and its consideration of placing the budget on an entirely assessed basis.

Eight Soviet-bloc members made a special offer to provide, in the form of plant, equipment and fellowships, one-third of the cost of a technical assistance program of establishing six medical centers and equipping six physics laboratories in developing countries, and providing 300 fellowships. The Conference directed the Board of Governors and the Director General to consider how this and similar offers could best be introduced into the Agency's program. The United States, for the fourth successive year, offered to donate special nuclear



IAEA Conference. The Sixth General Conference of the International Atomic Energy Agency in Vienna during September was characterized by the absence of significant disputes on items of major importance among the 72 member states. Photo shows Dr. Glenn T. Seaborg (*left*), Chairman of the U.S. Atomic Energy Commission, talking with Dr. Bertrand Goldschmidt, Director for Foreign Relations and Programs of France's Commissariat a l'Energie Atomique during the conference. In the background is Sir Roger Makins, Chairman of the United Kingdom Atomic Energy Authority.

material up to $50,000 in value for use in research on peaceful uses or for medical therapy. The United States also pledged $50,000 to the Agency's voluntary budget plus $250,000 on a matching basis.

Safeguards Against Diversion to Military Use

Inspections of U.S. reactors. The first and second tests of IAEA safeguards inspection procedures within the United States were carried out in June and November when two Agency representatives visited U.S. reactors which have been made available to the Agency for this purpose for a period of 1 to 2 years.

The United States had originally proposed Agency inspection of the four reactors at the IAEA Fourth General Conference in September 1960. This offer by the United States was made to lend support

to the Agency safeguards program and to further its development by providing in effect a field laboratory for IAEA inspection personnel. The Board of Governors at their February–March 1962 meeting approved an agreement between the United States and the IAEA to apply Agency safeguards to the following reactors for 2 years: the Brookhaven Graphite Research Reactor, the Brookhaven Medical Research Reactor, and the Piqua (Ohio) Nuclear Power Facility; and for one year to the Experimental Boiling Water Reactor at Argonne.

The application of Agency safeguards to the United States reactors provides for the submission of periodic and special reports and for Agency inspection of the facilities subject to safeguards. United States safeguard inspections under bilateral agreements are listed by date in Appendix 10.

IAEA-U.S.-Japan safeguards arrangement. Substantial progress has been made on a proposed trilateral agreement between the United States, Japan, and the IAEA under which the Agency would assume safeguards responsibilities for all nuclear facilities and materials transferred to Japan under the United States-Japan Agreement for Cooperation. As of December 1962, the draft agreement was under review by the Japanese Government.

Fuel Supply Agreements Concluded With Pakistan and the Congo

Under trilateral contracts concluded with the IAEA and Pakistan, and with the IAEA and the Congo, during 1962, the United States agreed to supply enriched uranium fuel for a research reactor in each of the two countries. The uranium will be supplied through the IAEA. The United States will provide special nuclear material for a five thermal megawatt research reactor being built in Pakistan with assistance of a U.S. reactor grant.

A 50 kilowatt (thermal) research and training reactor in operation since 1959 at the University of Lovanium in Leopoldville, Congo, will receive enriched fuel. In addition, title to Belgian reactor fuel purchased from the United States in 1958 and currently being used in the Lovanium reactor, was transferred to the Congo by Belgium through the Agency.

IAEA safeguards will apply to both facilities to assure that the reactors and fuel will be used only for peaceful purposes.

Similar agreements were concluded during 1960 and 1961 for the supply of U.S. fuel to be supplied through the Agency to reactors in Finland, Norway, and Yugoslavia.[8]

[8] See pp. 231 and 232, Annual Report to Congress, Jan.–Dec. 1961.

U.S. Assistance to IAEA

The following table summarizes U.S. assistance to the International Atomic Energy Agency during 1961 and 1962.

	1961[a]	1962
1. CONSULTANTS AND TECHNICAL ASSISTANCE EXPERTS		
a. Number of U.S. Cost-Free Consultants	9	14
b. Number of Countries Served	7	15
c. Cost to U.S. of cost-free U.S. consultants	$25, 512	$43, 872 (est.)
d. Number of U.S. Technical Assistance Experts on Assignment [b]	19	23
(Total Number of Technical Assistance Experts from all Countries on Assignment	55	85)
2. RESEARCH CONTRACTS		
a. Number of Research Contracts Financed by U.S.	9	14
(Total Number of Research Contracts by IAEA	84	111)
b. Amount Committed for Joint U.S.-IAEA Research Contracts	$147, 580	$182, 801
(Total Cost of IAEA Research Contracts	$576, 944	$950, 273)
3. EQUIPMENT GRANTS		
a. Value of U.S. Equipment Grants	$80, 000	$167, 500
4. FELLOWSHIPS		
a. Number of Type I Students Trained in U.S.[c]	31	30
b. Number of Type II Students Trained in U.S.[d]	70	67
5. IAEA BUDGET		
a. Regular Budget (Assessed)	$6, 168, 000	$6, 161, 000
U.S. Portion	$2, 000, 283	$1, 988, 155
b. Operational Budget (Voluntary)	$1, 800, 000	$2, 000, 000
U.S. Portion	$630, 970	$677, 783 (est.)
6. Total Amount of U.S. Nuclear Material Supplied to IAEA as of November 30, 1962: 56,314.52 grams of U–235 112.00 grams of plutonium		

[a] Figures for 1961 IAEA assistance as listed on p. 243 of 1961 Annual Report were estimated. The above figures for 1961 are actual.

[b] Technical assistance experts are employed and paid by IAEA.

[c] Type I fellowships are those financed by an appropriation from the IAEA General Fund.

[d] Type II fellowships are those financed by the host country.

OTHER FOREIGN ASSISTANCE

Foreign Training Programs

The Commission's international program includes both formal and informal training and research opportunities in the unclassified areas of all nuclear science. In general, the Commission does not provide training that is available elsewhere. Programs are reviewed to assure that there is no duplication of training and education programs available to meet the needs of foreign nationals.

International Institute

The International Institute of Nuclear Science and Engineering at Argonne National Laboratory, offers specialized advanced training and post-doctoral study in the nuclear fields. The programs include reactor science and technology, engineering research and development, physical science research, life science research, and engineering, administration and operation of nuclear facilities.

Reactor Courses

The AEC is offering two 12-month courses at the Oak Ridge National Laboratory in reactor operations supervision and in reactor hazards evaluation. Both provide intensive study in mathematics, engineering, physics and chemistry as related to the operation of reactors and the evaluation of local hazards.

Latin America Center

The Puerto Rico Nuclear Center, operated for the AEC by the University of Puerto Rico, was conceived primarily to aid Latin American nations in developing skills essential to nuclear energy activities, by providing graduate level education and research opportunities. Particular attention is being given to developing these facilities as a nuclear research center oriented toward the needs of the tropics.

Guest Scientists

During 1962 nearly 500 foreign scientists have participated in research or training courses in AEC facilities. In most cases these assignments serve a need of the foreign scientists to become familiar with the techniques and the various approaches being made in AEC

laboratories in specific fields of nuclear research and at the same time the AEC program benefits from the fresh outlook and unique capabilities of the guest scientists. Individuals from 66 countries have participated in Commission-sponsored training activities.

Research Reactor Utilization and Development

Turkish-BNL Cooperative Program

A cooperative arrangement was established between Brookhaven National Laboratory and the Turkish Cekmece Nuclear Center, site of Turkey's first research reactor toward which the United States contributed $350,000. Under the arrangement, Brookhaven will provide guidance in the establishment and execution of research projects.

Under the Brookhaven-Cekmece arrangement, complete responsibility for operation and utilization of the Center remains with Turkey. Brookhaven's assistance and guidance will be accomplished through exchange of visits by technical personnel and through correspondence. During the year, two technical experts were sent to Turkey to consult with the Cekmece staff.

Bangkok Meeting on Reactor Utilization

As a follow-up to work initiated at the IAEA Symposium on Programming and Utilization of Research Reactors held in Vienna in October 1961, the International Atomic Energy Agency sponsored a regional meeting in Bangkok, Thailand, during December 1962, to discuss the utilization of research reactors. It was attended by representatives from the majority of the recently established reactor centers in the Far East and Southeast Asia as well as from organizations throughout the world (including representatives from U.S. institutions) having considerable experience in planning and conducting reactor research programs. The primary objective of the meeting was to bring together the scientists from the centers in the area to discuss their experience and plans for research, and to describe their special needs and problems in effectively utilizing their facilities. Emphasis was on discussions of actual problems encountered and anticipated in the new centers and overall plans and programs. This regional meeting, in addition to providing guidance to scientists from the newly established centers, contributed to the formulation of concrete plans for additional cooperative research efforts and exchanges between the participants.

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Phase IIB of Halden Project

The Commission will continue its participation in the Halden boiling heavy water reactor project in Norway. Since July 1958, the Halden project has been operated as a joint undertaking of the European Nuclear Energy Agency and Norway, with the United States as a participant.

Under phase IIB, which runs from January 1963 until 1966, the United States will sell or lease to the project, through the IAEA, the special nuclear material required to fabricate 30 fuel elements and four natural uranium elements. In addition, the United States will also contribute $300,000 toward the cost of the research and development work. This research contract grants AEC free access to the Halden facility, and permits the AEC to assign a limited number of personnel to participate in the program and attend all technical meetings related to program's planning and direction. The contract also includes a provision requiring Norway, at the option of the United States, to return all those fuel elements purchased in the United States which have ruptured or failed during the program in order that AEC may examine the reasons for failure.

Participation in phase IIB will provide the United States useful information on the reactor dynamics of boiling heavy water reactors; will help develop mathematical techniques for testing boiling reactor dynamics; will verify U.S. calculation procedures and develop techniques for in-core instrumentation which could have important applications in future programs; and will provide useful information on the properties of tubular fuel assemblies.

United Kingdom

Pursuant to an arrangement made with the United Kingdom in 1958 under terms of the United States-United Kingdom agreement for cooperation, basic research information has been exchanged in the areas of controlled thermonuclear reactions, gas coolant compatibility, beryllium metallurgy, uranium dioxide fuels, and plutonium metallurgy. A recent agreement will add beryllium oxide to the program dealing with beryllium metallurgy. Negotiations are also virtually complete for the addition of basic research information pertaining to the chemical processing of irradiated fuel to the program.

In April and September 1962, U.S. teams visited Harwell, England, to exchange information on gas coolant compatibility and uranium dioxide fuel. Exchanges under this arrangement have been especially

useful in providing newly generated basic information rapidly to each participant, thus avoiding duplication, effecting economies, and facilitating the solution of mutual problems.

The philosophy of operating production reactors is another fruitful field for a collaboration which began in 1960. In December 1962, an AEC team visited the United Kingdom to hold unclassified discussions concerning equipment maintenance, safety systems, operating standards, staff training, and other facets of the operation of large scale production reactors.

There has also been an active exchange of information on feed materials in the production area. Collaboration on this particular exchange began in 1960 and six meetings have been held on this subject, the latest being in the United Kingdom during November 1962.

In the gas cooled reactor field, information has been exchanged on the development design, construction, and operation of the Advanced Gas Cooled Reactor (AGR) and HERO at Windscale in the United Kingdom in return for similar information on the U.S. Experimental Gas Cooled Reactor (EGCR) at Oak Ridge. Tangible results have been obtained in the past year in lowering capital costs of construction of the EGCR by making the overall design of the reactor and heat exchangers more compact and it is foreseen that more heat per ton of fuel will be obtained.

The United States and the United Kingdom also have an active exchange of information on fast reactors dating back to 1956. The United States is providing information on the EBR–I and EBR–II in exchange for U.K. information on the Dounreay fast reactor.

Canada

United States-Canadian collaboration on civil uses of nuclear energy has progressed, since its inception in 1955, from basic research in fuel cladding and reactor instrumentation technology to the current special program of cooperation on heavy water power reactor development and operation.

In the field of natural uranium, heavy water moderated and heavy water cooled type of reactor, Canada's Nuclear Power Demonstration Plant (NPD), which is now in operation, and the Douglas Point Plant (CANDU), presently under construction, are the world's most advanced design. Technology from these programs continues to be made available to the United States.

Dragon Project

The United States is continuing its cooperation with the Dragon Project, a research and development program on high temperature gas

cooled reactor technology undertaken jointly by the European Nuclear Energy Agency and Euratom.

Eurochemic

Cooperation with the Eurochemic Company, an international stock company sponsored by ENEA and composed of 13 European member nations is continuing. Eurochemic is constructing a plant at Mol, Belgium, for the chemical processing of irradiated fuel. Construction began in 1958. As a part of a continuing, effective exchange, the United States maintains a representative in residence at Mol.

Sweden

In May 1962, arrangements were developed between the United States and Sweden providing for the exchange of information pertaining to burn-out measurements in fuel rod bundles. The program is being coordinated by the Commission's Oak Ridge Operations Office.

Australia

The AEC concluded an arrangement with Australia in August 1962, to exchange information on high temperature gas-cooled reactors and related subjects. Specific topics to be covered in the exchange include chemical and metallurgical properties of beryllium and its compounds, nuclear physics data on reactor materials (including studies of neutron physics), coolant circuit technology, and waste disposal development and management.

Federal Republic of Germany

An arrangement with the Federal Republic of Germany provides for the exchange of information on a reciprocal basis on the German 15 megawatt, electrical AVR quasi-homogeneous, gas cooled pebble bed reactor and a follow-on prototype reactor. Information will be made available through reports, correspondence, and short term visits of personnel to both U.S. and German facilities with mutual assistance in related research and development work.

During 1962, the United States and West Germany agreed to establish close cooperation in all phases of fast reactor development under the fast reactor cooperative program which the United States is developing with Euratom.

Italy

The Commission, in November 1962, concluded a Memorandum of Understanding with the Italian National Committee for Nuclear Energy (CNEN) looking toward reprocessing of the irradiated first core of the Elk River boiling water power reactor in the Italian uranium-thorium reprocessing and fuel fabrication plant through a lease agreement with Euratom under which AEC would pay the CNEN a fixed price for the services. Information gained from the reprocessing and from the use of the fuel elements if they are reinserted in the Elk River reactor would be available to both countries. The reprocessing and refabrication would be carried out in facilities that have no counterpart outside Italy, and the benefits derived from the project will be far in excess of the cost to either nation.

The Netherlands

A technical exchange pursuant to the United States-Netherlands agreement provides that work being done in the KEMA Laboratories on homogeneous slurry reactor and related slurry fuel research and development will be made available to the United States. An engineer with extensive experience with the Oak Ridge aqueous homogeneous reactor work has been assigned to the KEMA Laboratories for one year. Euratom has a contract of association with The Netherlands for the KEMA project and is therefore also a party to this exchange.

Agreements for Cooperation

Amendments to 14 United States Agreements for Cooperation in the civil uses of atomic energy were concluded during the past year with Euratom (two agreements), West Berlin, Brazil, Canada, China, France, Germany, Greece, Israel, Portugal, Sweden, South Africa, and Thailand. A superseding agreement was also concluded with Argentina.

Both the 1959 and 1960 agreements with Euratom were amended. A major provision of the amendment to the 1958 agreement permits the lease as well as sale of enriched uranium for power reactors under the United States-Euratom joint reactor program. Other significant provisions afford indemnity protection to the United States and modify the patent article so as to limit to the atomic energy fields certain license rights granted as a result of inventions made under the joint research and development program.

A major provision of the amendment to the 1960 Euratom agreement permits the distribution to Euratom of 3,000 kilograms of

uranium 235 for a wide variety of civil uses, including the fueling of many types of research and power reactors. The United States is also permitted to transfer to Euratom additional amounts of plutonium and uranium 233 as may be agreed and authorized by Congress.

In addition, the amended 1960 agreement now permits, subject to U.S. approval, the chemical processing, conversion, and fabrication in the European Community of special nuclear material obtained from the United States and the subsequent transfer of such material to third countries.

Amendments to the bilateral agreements with individual countries were concerned with increasing the quantities and enrichment of material provided them by the United States, allowing certain countries to have third country fabrication rights, and extending the period of the agreements for 2 years. The agreement with West Berlin was extended for 5 years. The agreement with South Africa was amended to permit it to lease as well as purchase uranium 233 for use in reactors.

RESEARCH REACTOR AND EQUIPMENT GRANTS

Reactors

Korea, Sweden, Turkey and Thailand received U.S. reactor grant payments of $350,000 each during 1962 for completed research reactors. Commitments for similar grants were made to Argentina, Colombia, and Iran to be paid upon completion and satisfactory operation of research reactors in those countries. All of the reactors, except Argentina's, are of U.S. manufacture. The Argentine reactor is being built by the Argentine National Atomic Energy Commission. To date the United States has paid 18 reactor grants, totaling $6,300,000, and has commitments for eight others.

Equipment

Nuclear equipment grants totaling $491,080 were committed by the United States to the International Atomic Energy Agency and four countries during 1962 to encourage the development of the peaceful applications of atomic energy.

The largest grant—for equipment valued at $161,500—was made to the International Atomic Energy Agency. This grant was apportioned by the Agency to seven member nations—Argentina, Brazil, Ceylon, Korea, Pakistan, the Philippines, and Portugal—under individual grants of equipment relevant to studies in the fields of agriculture, medicine, radiochemistry, and nuclear physics. A

TABLE No. 5.—AGREEMENTS WITH INTERNATIONAL ORGANIZATIONS IN THE CIVIL USES OF ATOMIC ENERGY

		Effective Date
1. International Atomic Energy Agency (IAEA).	Supply of Materials, etc.	Aug. 7, 1959
2. European Atomic Energy Community (EURATOM).[b]	Joint Nuclear Power Program.	Feb. 18, 1959
3. European Atomic Energy Community (EURATOM).[b]	Additional Agreement	July 25, 1960

AGREEMENTS WITH OTHER NATIONS IN THE CIVIL USES OF ATOMIC ENERGY

Countries	Agreements	Country	Scope	Effective Date	Termination Date
1	1	Argentina	Research [b]	7-29-55	7-27-64
2	2	Australia [a]	Research & Power	5-28-57	5-27-67
3	3	Austria	Research	1-25-60	1-24-70
4	4	Belgium [a]	Research & Power [b]	7-21-55	7-31-65
5	5	Brazil	Research [b]	8- 3-55	8- 2-64
6	6	Canada [a]	Research & Power [b]	7-21-55	7-13-80
7	7	China, Rep. of	Research [b]	7-18-55	7-17-64
8	8	Costa Rica	Research	2- 8-61	2- 7-66
9	9	Denmark	Research [b]	7-25-55	9- 7-68
10	10	Ecuador	Research	2- 6-58	2- 5-63
11	11	France	Research & Power [b]	11-20-56	11-19-66
12	12	Germany, Fed. Rep.	Research & Power [b]	8- 7-57	8- 6-67
	13	W. Berlin, City	Research [b]	8- 1-57	7-31-67
13	14	Greece	Research [b]	8- 4-55	8- 3-64
14	15	Indonesia	Research	9-21-60	9-20-65
15	16	Iran	Research	4-27-59	4-26-64
16	17	Ireland	Research [b]	7- 9-58	7- 8-63
17	18	Israel	Research [b]	7-12-55	7-11-64
18	19	Italy	Research & Power [b]	4-15-58	4-14-78
19	20	Japan	Research & Power [b]	12- 5-58	12- 4-68
20	21	Korea, Rep. of	Research [b]	2- 3-56	2- 2-66
21	22	Netherlands [a]	Research & Power [b]	8- 8-57	8- 7-67
22	23	Nicaragua	Research	3- 7-58	3- 6-63
23	24	Norway	Research & Power	6-10-57	6- 9-67
24	25	Philippines	Research [b]	7-27-55	7-26-63
25	26	Portugal	Research [b]	7-21-55	7-20-64
26	27	South Africa	Research & Power [b]	8-22-57	8-21-67
27	28	Spain	Research & Power	2-12-58	2-11-68
28	29	Sweden	Research [b]	1-18-56	6- 1-68
29	30	Switzerland	Research	7-18-55	7-17-65
	31	Switzerland [a]	Power [b]	1-29-57	1-28-67
30	32	Thailand	Research [b]	3-13-56	3-12-65
31	33	Turkey	Research [b]	6-10-55	6- 9-65
32	34	United Kingdom [a]	Research & Power [b]	7-21-55	7-20-65
33	35	Venezuela	Research & Power	2- 9-60	2- 8-70
34	36	Viet-Nam	Research	7- 1-59	6-30-64

See footnotes at end of table.

MUTUAL DEFENSE AGREEMENTS

1.	NATO [a]	Mar 29, 1956
2.	Australia [a]	Aug 14, 1957
3.	Belgium	Sep 5, 1962
4.	Canada [a]	Jul 27, 1959
5.	France	Jul 20, 1959
6.	France [a]	Oct 9, 1961
7.	Germany, Fed. Rep. [a]	Jul 27, 1959
8.	Greece [a]	Aug 11, 1959
9.	Italy [a]	May 24, 1961
10.	Netherlands [a]	Jul 27, 1959
11.	Turkey [a]	Jul 27, 1959
12.	United Kingdom [a]	Aug 4, 1958
	(Amendment to U.K. Agreement) [a]	Jul 20, 1959

SUMMARY

In effect: 22 research and 14 power agreements with 34 countries and West Berlin, 12 Mutual Defense Purposes Agreements, and 3 special agreements (IAEA and Euratom). A research agreement with Colombia will come into effect upon the exchange of notes between the United States and Colombia. A power agreement with Brazil has been signed but not ratified by Brazil.

[a] Classified Information Agreements.
[b] Denotes Agreement has been amended.

supplementary grant of $6,000 was made to cover the cost of a mass spectrometer for Iceland.

Other equipment grants totaling $323,580 were approved by the Commission:

Mexico—$159,080 to assist the National Autonomous University of Mexico to obtain a three Mev (million electron volt) linear accelerator,

India—$112,000 for equipment to be used in a radiation medical center to be established at the Tata Memorial Institute in Bombay,

Argentina—$40,500 for a nuclear and solid state physics program at LaPlata University, and

Brazil—(two grants) $12,000 for a cobalt 60 irradiator for the University of Brazil; and in the latter half of 1961, $2,250 was committed to Brazil to assist in obtaining three polonium and beryllium sources.

MATERIALS

The sale and lease of nuclear materials to other countries continues to provide a large return of dollars to the AEC. Approximately $11 million has been paid to the Commission by foreign countries for the purchase of special nuclear material. In addition, nearly $10.7 million worth of heavy water has been sold abroad. Total uranium valued at $29.1 million and heavy water valued at $2.8 million have been leased to other countries by AEC.

The stepped up level of activity in the nuclear energy field abroad is reflected in the fact that the quantities of most U.S. supplied special nuclear materials and heavy water shipped abroad during 1962 to other countries more than doubled over those of 1961.

NUCLEAR SHIP ACTIVITIES

During 1962, Greece and West Germany signed port acceptance agreements with the United States under which the nuclear-powered merchant ship, N.S. *Savannah*, may enter Greek and West German ports. The agreements cover such matters as port clearance procedures and nuclear liability. Individual approval will be required prior to each visit of the *Savannah*. Negotiations for acceptance agreements are in progress with the following 10 countries: Belgium, Denmark, France, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

NUCLEAR LIABILITY

During 1962, the Commission continued to participate, in cooperation with other agencies of the U.S. Government, in the development of adequate international standards to govern civil liability for nuclear damage and in encouraging other governments to provide adequate financial protection to the public, the operators of nuclear facilities, and the suppliers of nuclear equipment.

Maritime Convention

A Convention on Liability of Operators of Nuclear Ships, which had been drafted in April 1961, was completed and opened for signature at a diplomatic conference in Brussels in May 1962. Thirteen countries have signed the convention. The United States took part in the development of this convention, but has not become a signatory.

IAEA Land-Based Convention

The IAEA's Board of Governors will convene a diplomatic conference early in 1963 to prepare an international convention on Minimum International Standards Regarding Civil Liability for Nuclear Hazards arising from land-based nuclear installations and the transport of nuclear materials. In October 1962, there was a second meeting of the 14 member intergovernmental panel which had prepared a number of articles of a draft convention in May 1961. Independently, and looking toward a possible third-party liability convention for the Western Hemisphere, a five-member intergovernmental committee

was appointed by the Inter-American Nuclear Energy Commission to study the problem of third-party liability. The United States participated in both of the above panels.

Other Activities

Progress was also made in other areas of the nuclear liability field. Most of the 16 signatories of the Organization for Economic Cooperation and Development (OECD) liability convention (the Paris convention of 1960) participated in the development of a supplement to that convention which would increase the limit of liability from $70 million to $120 million, and include provision for governmental indemnification. The Paris convention itself came into effect upon its ratification by five signatories. Relevant national legislation on third party liability was enacted in Japan, Belgium, and the Philippines, and was introduced in a number of other countries.

EAST-WEST EXCHANGE PROGRAM ACTIVITIES—1962

On March 8, 1962, the United States and the Soviet Union signed a new agreement for scientific, technical, educational, and cultural exchanges for 1962–63, including the continuance, for a period of 2 years, of the reciprocal exchange program in the unclassified areas of the peaceful uses of atomic energy. The atomic energy section of the new agreement replaces the 1960–61 Memorandum on Cooperation.

Arrangements were made through diplomatic channels to exchange a United States and Polish scientist for a period of 1 year. A U.S. scientist is now in Poland conducting research at the Institute of Nuclear Research at Swiork, while it is anticipated that his Polish counterpart will arrive in the spring of 1963 for research study at the Brookhaven National Laboratory. This reciprocal exchange, which involves research for extended periods in U.S. and Polish nuclear laboratories, is the first of its kind to be arranged between the two countries.

Two U.S. scientists visited corrosion chemistry facilities in the Soviet Union during June 1962, in exchange for visits to U.S. facilities by Soviet scientists following their attendance at the 1960 Gordon Conference on Nuclear Chemistry at Colby Junior College, New London, N.H.

Agreement was reached with the Soviets to implement a reciprocal exchange of visits of specialists in the fields of waste disposal and power reactor development and itineraries were agreed upon. However, the Soviets were unable to accommodate the visits as planned and the exchanges were postponed. They may take place at a later date.

In accordance with the terms of the U.S.-U.S.S.R. Memorandum on Cooperation, which provides for the exchange of unclassified information, a group of documents representing the work of U.S. scientists in the fields of the peaceful uses of atomic energy, was shipped to the Soviet Union. A similar shipment of documents was received from the Soviets last year. The United States is currently exploring with the Soviets proposals to extend the exchange of unclassified scientific information.

INTERNATIONAL CONFERENCES AND EXHIBITS

The Commission's international conference support and international exhibits activities continued, during 1962, to implement successfully the "Atoms for Peace" program and to assist in the dissemination of information throughout the scientific and industrial communities of the world. The activities are administered by the Commission's Division of Special Projects.

INTERNATIONAL SCIENTIFIC CONFERENCES

During 1962, the AEC continued its program of financial support of international conferences convened to examine specialized scientific areas of nuclear energy and to foster the exchange of scientific information with foreign countries.

Topical Conferences

Topical conferences sponsored by private U.S. and/or international scientific organizations stimulate the free exchange of scientific information, evaluate new information made available at the time of the meetings, and focus international attention on the subject matter under discussion at the specific meetings.

Important benefits have resulted from conferences supported by the AEC over the years. A recent example resulted from the Conference on Corrosion of Reactor Materials, Salzburg, Austria, June 4–9, 1962. Several laboratories in various countries reported on their work on similar projects. The same problems were being attacked by different methods, thus one laboratory might obtain results that might have been overlooked by others. This exchange of views offered a

potential saving of time and effort to the various laboratories involved.

The following is a list of international conferences financially supported and/or participated in by the AEC during 1962:

TABLE NO. 6.—TOPICAL CONFERENCES

Title	Sponsoring Organization	Place	Date	AEC Program Interest
Sector Focused Cyclotrons.	Univ. of California	Los Angeles, Calif.	Apr. 17–20	Div of Research.
Transfer of Calcium and Strontium Across Biological Membranes.	Cornell Univ	Ithaca, N.Y.	May 13–16	Div. of Biology and Medicine.
Biology of the Transuranic Elements.	General Electric Co., Hanford Atomic Products Operation.	Richland, Wash.	May 17–19	Div. of Biology and Medicine.
Basic Mechanisms in Animal Virus Biology.	Long Island Biological Assoc.	Cold Spring Harbor, N.Y.	June 6–13	Div. of Biology and Medicine.
VIII International Cancer Congress.	Nat'l. Academy of Sciences.	Moscow, U.S.S.R.	July 22–28	Div. of Biology and Medicine.
Radiation Research	Nat'l. Academy of Sciences.	Harrogate, England.	Aug. 5–11	Div. of Biology and Medicine.
Limnology	American Society of Limnology and Oceanography.	Madison, Wis.	Aug. 20–25	Div. of Biology and Medicine.
Radiation and Radioisotopes in Pharmacology.	American Society Pharmacology and Experimental Therapeutics.	Nashville, Tenn.	Aug. 27–29	Div. of Biology and Medicine.
Electron Microscopy.	Electron Microscope Society of America.	Philadelphia, Pa.	Aug. 29–Sept. 5.	Div. of Biology and Medicine.
Plutonium as a Power Reactor Fuel.	American Nuclear Society.	Richland, Wash.	Sept. 13–14	Div. of Reactor Development.
Effects of Radiation on the Reproductive System.	Colorado State Univ.	Ft. Collins, Colo.	Sept. 17–19	Div. of Biology and Medicine.
Application of Computers to Nuclear and Radiochemistry.	Nat'l. Academy of Sciences.	Washington, D.C.	Oct. 18–19	Div. of Research.
Saline Deposits	Nat'l. Academy of Sciences.	Houston, Tex.	Nov. 12–14	Div. of Research, Div. of Peaceful Nuclear Explosives.
Radiation-Induced Polymerization and Graft Copolymerization.	Batelle Memorial Institute.	Columbus, Ohio	Nov. 28–29	Div. of Isotopes Development.

TABLE NO. 7.—INTERNATIONAL ATOMIC ENERGY AGENCY CONFERENCES

Title	Place	Date	No. of U.S. Participants	No. of Participants at AEC Expense
Radiosotopes in Soil Plant Nutrition Studies.	New Delhi, India	Feb. 26–Mar. 2	4	4
Radiation Damage in Solids and Reactor Materials.	Venice, Italy	May 7–11	31	17
Reactor Safety and Hazards Evaluation Techniques.	Vienna, Austria	May 14–18	14	6
Thermodynamics of Nuclear Materials.	Vienna, Austria	May 21–25	37	24
Corrosion of Reactor Materials	Salzburg, Austria	June 4–9	20	14
Biological Effects of Ionizing Radiation.	Brno, Czechoslovakia	July 2–6	7	7
Inelastic Scattering of Neutrons	Chalk River, Canada	Sept. 10–14	10	7
High Level Radioactive Wastes	Vienna, Austria	Oct. 8–13	15	10
Radioactive Dating	Athens, Greece	November	14	10
Practical Applications of Short-Lived Radioisotopes.	Vienna, Austria	Nov. 5–9	10	5
Neutron Detection, Dosimetry and Standardization.	Harwell, England	Dec. 10–14	35	20
Total			197	124

INTERNATIONAL SCIENTIFIC EXHIBITS

International nuclear energy exhibits are comprehensive presentations for demonstrating overseas to scientific and public audiences many of the more important and newest U.S. peaceful applications of atomic energy. The AEC's exhibit programs are presented in response to requests from, and shown in cooperation with, foreign governments' nuclear energy establishments. These comprehensive displays are reviewed and coordinated in detail with the Department of State, the U.S. Information Agency, and with the Interagency Exhibits Committee.

Program Objectives

The international exhibits program of the AEC was initiated in 1957 to meet the following objectives:

1. To enable scientists of the host country to work at their own scientific projects with a nuclear reactor, a gamma irradiation facility, and other operating nuclear equipment, under the guidance or with the assistance of the American staff.
2. To demonstrate to science students and teachers some of the latest methods of teaching science, with emphasis on nuclear science.



Royal Visitor. Queen Frederika of Greece, internationally known for her interest in atomic energy, was an interested spectator when the Commission's "Atoms At Work" exhibit was displayed in Athens during May and June. Photo shows the Queen inspecting the Brookhaven National Laboratory's cobalt 60 gamma irradiation facility which is one of the primary attractions of the exhibit. Queen Frederika visited in 1958 and displayed a knowledgeable interest while touring several of the AEC's reactor and research facilities.

3. To demonstrate and explain to the general public some of the more interesting beneficial uses of atomic energy.

Exhibit Composition

Each exhibit is housed in its own portable building and is composed of a "scientific institute" and a "public display area".

The scientific institute has a separate entrance, making it possible for technically oriented visitors to have unimpaired access to exhibit equipment. This section is composed of:

1. An operating nuclear training and research reactor plus modern U.S. laboratory equipment and nuclear instrumentation, staffed by a U.S. reactor program supervisor and three contract reactor operators.
2. A 2,000-curie, cobalt 60 pool-type gamma irradiation facility operated by scientists from the Commission's Brookhaven National Laboratory.

3. An Oak Ridge Institute of Nuclear Studies (ORINS) student-teacher demonstration program, staffed by members of ORINS. Selected host country high school teachers and students are trained in the ORINS methods. In several instances, Latin American teachers under a cooperative arrangement were trained at ORINS in Oak Ridge, Tenn., before returning to their countries to handle the exhibit classroom lectures.
4. A technical Information Center, where representative samples of AEC publications and U.S. commercial scientific textbooks (complementing the ORINS and other technical programs of the exhibit) are available for inspection and use. Professional assistance is provided by a representative of the Commission's Technical Information Division. In addition, selected films on the uses and applications of atomic energy are shown in a small theater.
5. Seminars and demonstrations given by U.S. scientists for host country scientific personnel and graduate students are an additional function of the exhibit.

Public Display Areas

In one of the six Public Display Areas of the exhibit, visitors see their scientists and U.S. scientists working with the most advanced operating nuclear equipment available. Films and more elementary demonstrations and explanations introduce the lay observer to the many beneficial uses of atomic energy.

Descriptions of the applications of nuclear energy in agriculture, medicine, and industry are given, as well as lectures on the fundamentals of nuclear reactors. Operating medical equipment can be viewed and is described, as is the whole display, to the visitor by trained host-country graduate students and scientists acting as guides. Thus, with a special introductory film on the basic uses of nuclear energy, and informational material relating to reactors, medicine, agriculture, and industry, visitors leave the exhibit better informed concerning the many peaceful applications of nuclear energy.

Industrial Participation in Exhibits

The year 1962 showed increasing interest by members of the U.S. atomic energy industry to cooperate with the AEC in the opportunity of introducing their products to the scientific community abroad. Approximately 50 industrial firms participated with models and operating equipment for inclusion in international exhibits. These displays have generated a number of foreign requests to buy equipment so displayed. Although actual sales activity at the exhibit site is prohibited, the displayed equipment is permitted to bear conven-

tional manufacturer's plates and descriptive brochures are available. American industrial firms have also sent their scientists to lecture at the Commission's overseas exhibits. The Commission also leases operating research and training reactors for each exhibit from commercial sources. In addition to major pieces of nuclear equipment, the Commission procures from industry numerous small exhibit components and parts, and such architectural engineering services as required for exhibit building and exhibit fabrication.

Tangible Benefits

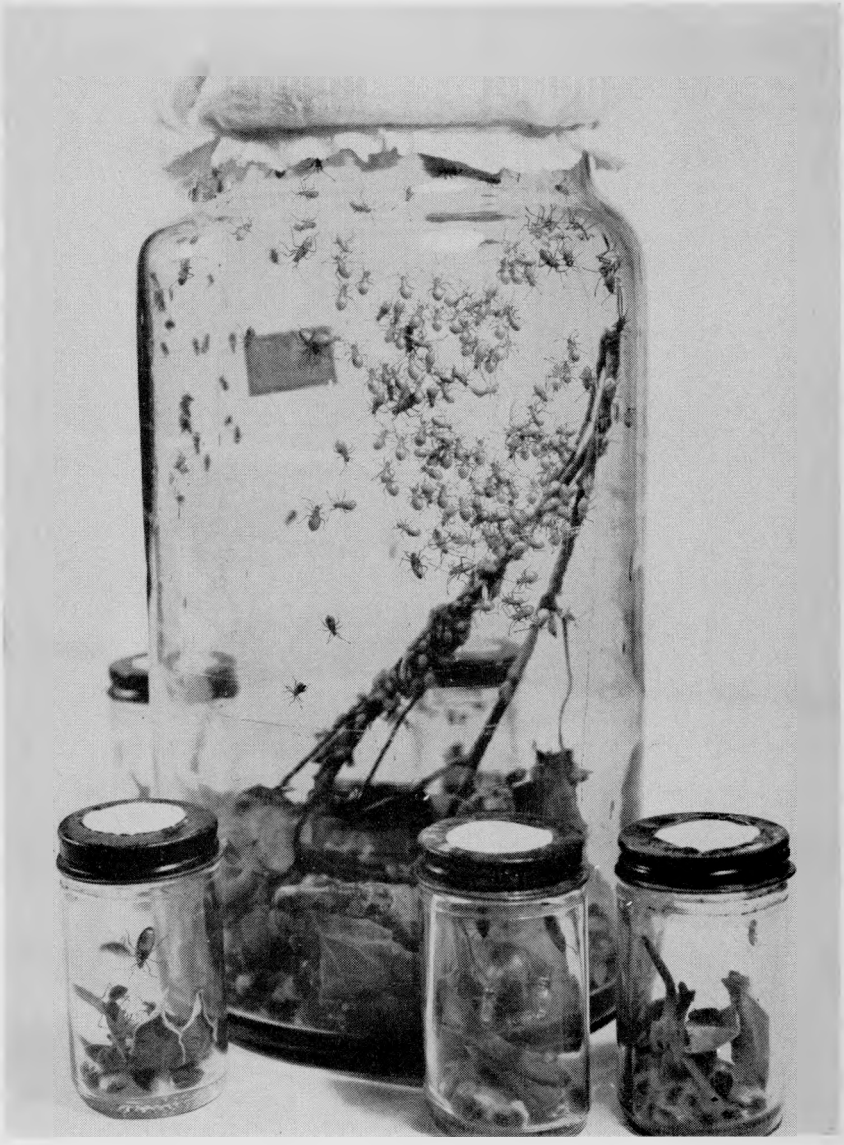
The outcome of research initiated during the course of an exhibit can have a direct impact on the people of the host country. The following are examples of applied research conducted with the cobalt 60 gamma irradiation facilities at various exhibits while some of the studies referred to here were conducted during exhibits held prior to 1962, the results of these experiments are currently just being made known.

Chagas disease. A high toll of lives in South America, particularly among lower income families, is taken annually by *Chagas* disease. It results from excrement deposited by the insect *Trypanasoma Cruzi* on the skin of the victim.

During the Rio de Janeiro exhibit in the spring of 1961, the Health Service of Bahia Province, brought living bugs to the exhibit to test the possibility of sterilization and control of the male by irradiation and the possibility of developing a non-deadly mutant. This work phase of the research was found possible.

A second study was made approaching the treatment of Chagas disease from the standpoint of serumology. Blood cultures were irradiated with the hope of developing a nonvirulent culture strain as a basis for producing an antitoxin. Actual blood culture samples were irradiated at varying levels and then tested on animals. Samples were tested at all levels of irradiation dosage. A definite reduction in virulence of the serum resulted. In each instance, the virulence was retarded as the irradiation dosage was increased. Those tests (due to limitation of time) were not conclusive and require further development of cultures and testing of serums. The presence of the AEC exhibit with its 2,000-curie cobalt 60 gamma facility allowed the basic research to implement this new approach. Continuation of this original research may develop a culture from which a serum could result that would immunize South Americans against the dread Chagas disease.

Induced hybridization. At the Cairo, Egypt, May 1960, exhibit scientists connected with the Egyptian atomic energy establishment



Irradiated Insects. Peru's famous long-staple cotton crops have been endangered by a strain of DDT-resistant Arrebiatado (*Diasdercus Ruficolis*) insects. While the Commission's "Atoms at Work" exhibit was being shown in Lima, Peruvian scientists, assisted by Brookhaven National Laboratory personnel, began a study of the insect's life patterns to determine if the Arrebiatado can be eradicated by radiation sterilization. Photo shows adult and half-grown insects which were grown from pupae irradiated in the exhibit's 2,000-curie, cobalt 60 pool-type gamma irradiation facility to determine whether they could be sterilized by this method.

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conducted extensive radiation studies with chickens leading to beneficial results of induced hybridization of the species.

Insect sterilization. Since the successful 1958–59 screwworm fly irradiation project in the southeastern United States, many countries with particular pest problems indigenous to their area have been attempting the sterilization of insects by irradiation. In Lima, Peru, during October 1961, steps were taken to determine the feasibility of irradiating the Arrebiatado, an insect which is responsible for failures of the Peruvian long-staple cotton crops. In Beirut, Lebanon, during the fall of 1961, scientists from the atomic energy liaison committee organized an irradiation program to eradicate the Mediterranean Fruit Fly.

Improving avocado plants. Continuing by irradiation, what ordinarily would take years, by natural selection, in Mexico City (April 1962) scientists from the Agricultural Institute irradiated avocado cuttings in the gamma-pool of the exhibition. It is anticipated that many years of research leading to an improved strain of plant were compacted into the 30-day exhibit irradiation program.

Bone grafting. One significant service was the irradiation of bones for grafting to replenish a bone bank at a local hospital in Athens, Greece, during the spring of 1962.

These, and many other studies of practical importance to mankind were given their start at the gamma irradiation facilities of the "Atoms at Work" Exhibitions. Scientists at the Brookhaven and Oak Ridge National Laboratories keep in periodic contact with the technicians and scientists of the countries visited by the exhibits.

Student Demonstration Facility

One of the most meaningful and important portions of the exhibit is a classroom-laboratory for secondary level students and their teachers. Here classes are held by host country teachers on subjects of radioactivity, basic nuclear physics and applied physics, and chemistry. Host country teachers are trained in the many teaching techniques by specialists of the Oak Ridge Institute of Nuclear Studies either in the host country or in the United States, when such arrangements can be made.

The classes are so heavily attended that due to local demand the host countries ordinarily continue these classes many months after the exhibit has closed. In Argentina and Brazil, this special training is already being incorporated into the regular school curriculum. Mexico and Chile have also expressed need to continue this training formally as part of their educational system.

National Science Fair

Science fair programs, under the direction of Science Service, Inc., of Washington, D.C., and supported by the AEC in cooperation with the host country's Ministry of Education, were initiated in Mexico and Chile during 1962. This same type program is planned for Colombia during 1963.

In 1962, students in the secondary schools in Mexico and Chile undertook scientific projects and demonstrations. Experimental kits consisting of six units of "Things of Science" devoted to atomic energy, mathematics of the straight line, chemical models, acidity test papers, pendulum, and atomically irradiated seeds, were made available from the United States through Science Services, Inc., for the students. The students were encouraged, with the cooperation of their teachers, to undertake projects in any field of science. The final winners of each country were allowed to display their projects in the AEC international exhibit being presented.

Educational authorities of both countries were pleased with the success of these science fairs as a means of enhancing the training of those who will be the scientists and engineers of the future. It is expected that science fairs in the above mentioned countries will become annual events and colleges, industry and scientific laboratories, as well as Government agencies will cooperate in the sponsoring of such fairs.

Exhibit Activity Statistics

The following table gives a summary of major exhibit activities:

1962 EXHIBIT ACTIVITY STATISTICS

Date	*Mexico City* April–May	*Athens* May–June	*Santiago* Oct.–Nov.	*Bangkok* Nov.–Dec.
Total attendance	148, 490	80, 000	104, 090	127, 000
Student - Classroom programs attendance	7, 000	3, 790	4, 360	8, 060
Reactor experimental programs attendance	3, 260	800	1, 570	2, 794
Reactor experimental programs experiments including special seminars	27	23	11	25
Gamma Irradiation facility studies	12	14	43	----------
Technical Information Center attendees	400	950	3, 360	4, 100
Special groups—Number of attendees	5, 500	13, 000	4, 880	5, 350
Medical Program - Demonstrations	15	60	29	30

Future Exhibits

The Latin American exhibit will be shown in Bogota, Colombia, April 1963. The European-Eastern exhibit will be shown in Vienna, Austria, during May 1963.

BIOLOGY AND MEDICINE

The Commission's biological, medical, and environmental sciences programs cover a wide range of effort in scientific areas of research which are intended to provide better understanding of the principles, mechanisms, and implications of the effects of radiations on biological systems. From these come data which extend and refine the existing scientific guidance for the control of exposure to radiation and radioactive materials. The program also includes studies of specialized problems of health and safety in atomic energy operations and development of beneficial applications of nuclear materials and atomic energy.

These three broad categories of research include a number of individual sub-programs which are mutually dependent for scientific progress. The results of basic and some applied research and development work in these areas are described in a special Commission report supplementing this Annual Report to Congress.[9]

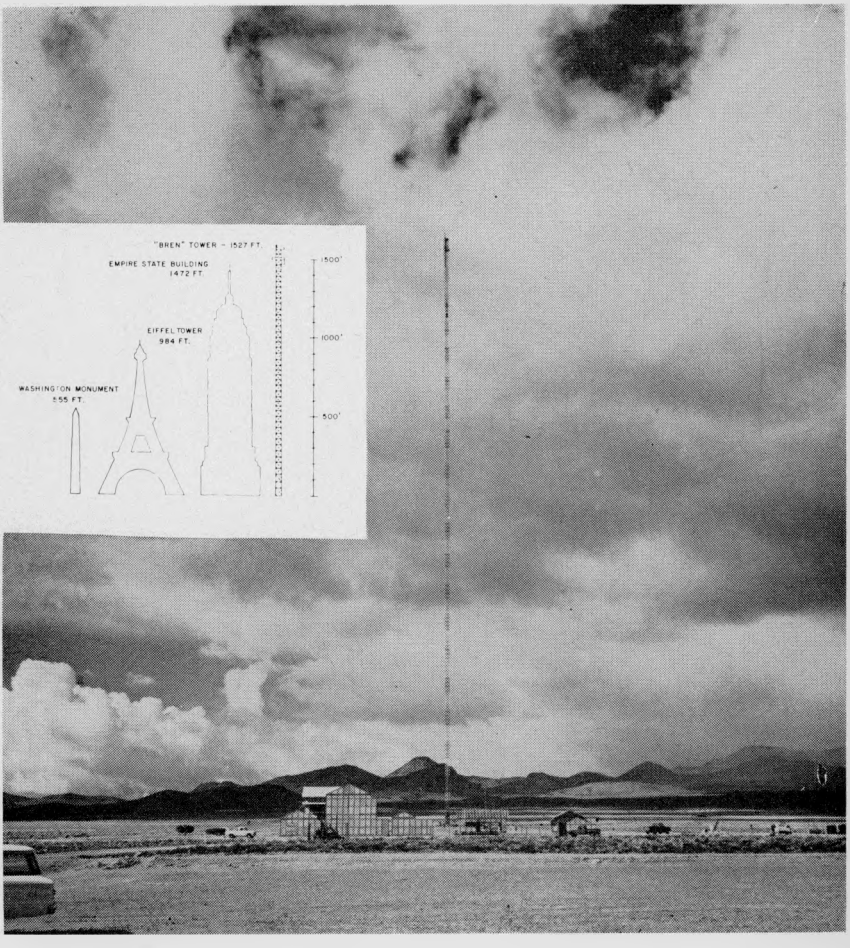
For research in the biological, medical, and environmental fields—life sciences—the Commission's Division of Biology and Medicine expended $58.3 million in operating expenses for the fiscal year that ended June 30, 1962. Some $37.0 million of this total was for research and operating expenses of Government-owned or financed laboratories operated for the Commission by universities or industrial organizations, and some $21.3 million was for research carried out in universities, colleges, and other institutions under 639 research contracts. In addition, $6.1 million was obligated for construction projects and capital equipment related to research in the life sciences. This Annual Report to Congress describes selected major activities during the past year related to nuclear civil effects, studies of inhaled fission products, and research facilities under construction. Results of basic research in life sciences at major Commission installations, universities, and colleges are described in the special report mentioned above.

NUCLEAR CIVIL EFFECTS

For a number of years the Atomic Energy Commission has supported research to learn more of the mechanisms by which radiation injury occurs in man. Of special importance has been the work of the

[9] "Fundamental Nuclear Energy Research—1962," available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

Atomic Bomb Casualty Commission which carries out, in Japan, a program to study survivors of the weapon bursts at Hiroshima and Nagasaki. From this study, much valuable data have been accumulated in the form of medical histories. In order to properly relate the medical data to radiation dosages received by the survivors at the time of the detonations, it is essential to estimate the dose as accurately



"BREN" Tower. In order to properly relate the medical data obtained among survivors of the Hiroshima and Nagasaki atomic detonations to the actual radiation doses received, the AEC has been conducting a series of experiments at its Nevada Test Site. Major facility for the test has been an unshielded reactor which has been hoisted to various altitudes on the 1,527-foot BREN (Bare Reactor Experiment, Nevada) tower. Dosimeters are placed inside Japanese-style houses and portions of houses as well as on the open terrain to determine how much the structures lessen the amount of radiation that would strike an individual. The inset drawing illustrates the height of the tower in relation to the Washington Monument, the Eiffel Tower, and the Empire State Building.

as possible since no actual radiation dose data were obtained from the detonations over the two cities.

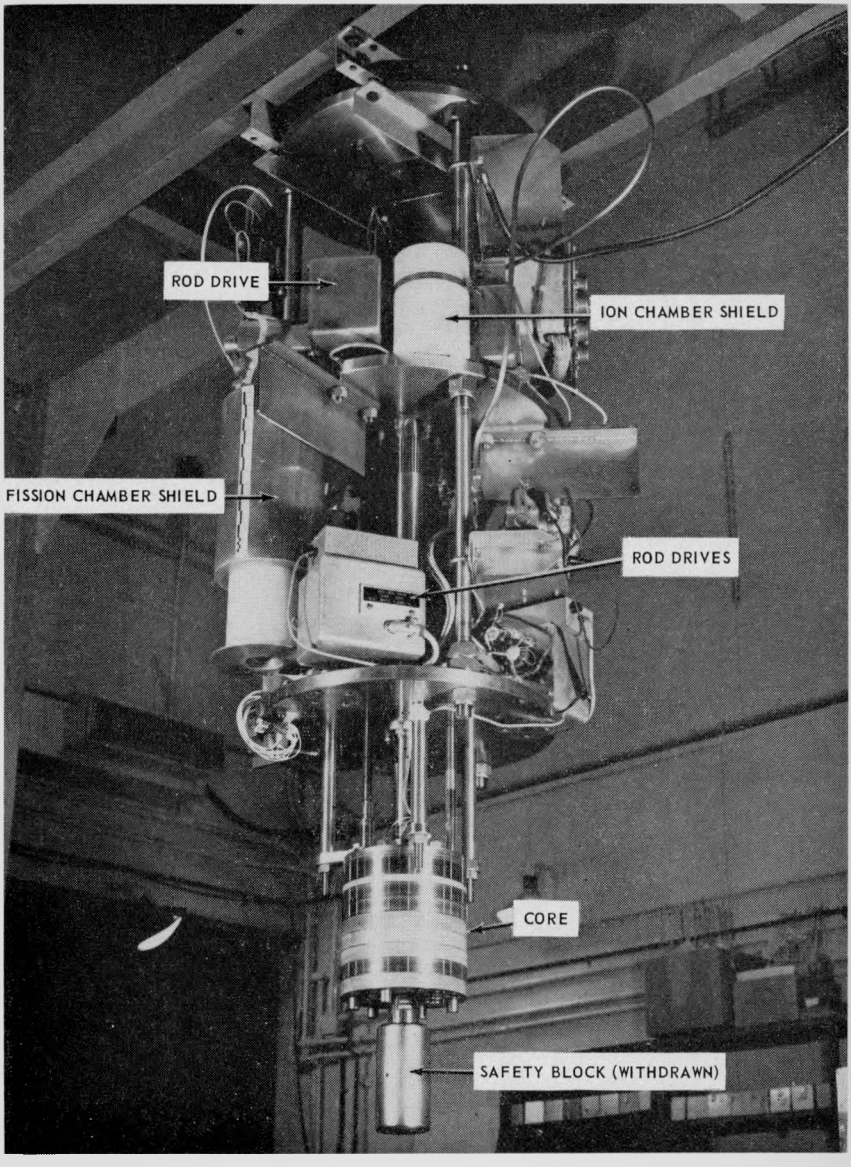
Dose Estimation Studies

At the outset of the Hiroshima-Nagasaki study it was recognized that many of the survivors had been shielded to some degree from the gamma radiation and the neutrons emitted by the explosions. This made it necessary to develop methods for dose estimation which would take into account the attenuation of the nuclear radiations by houses, buildings, walls, and other objects. Similarly, knowledge of the propagation and refraction of gamma rays and neutrons in air had to be refined so that an accurate interpretation of the change of gamma and neutron dose with distance and the effect of the shielding could be put into calculations. This required the development of dosimetric systems which could measure gamma radiation in the presence of neutrons, and neutron radiations in the presence of gamma rays. Such systems were tested successfully during the 1955 weapons tests at the Nevada Test Site.

Field tests. During the 1957 and 1958 Nevada test series, field programs were conducted to measure the energy and angular distribution of gamma rays and neutrons from nuclear weapons. Facsimiles of Japuanese houses were constructed for use in these experiments, and dosimeters were used to measure radiation doses at various locations inside and outside the houses. While much significant information was obtained, analyses showed that the accuracy of the data would not suffice for the studies of the Japanese survivors. For example, the neutron dose for the Hiroshima weapon might vary by a factor of two and the gamma dose could not be estimated closer than plus or minus 50 percent.

OPERATION BREN

Because of the moratorium starting in November 1958, on nuclear weapons tests, an alternative method was required to further the studies. Scientists at Oak Ridge National Laboratory concluded that an unshielded nuclear reactor could be used as the source of neutrons and gamma rays. For this purpose, Operation BREN (Bare Reactor Experiment, Nevada) was conducted during 1962. In order to avoid perturbations from air-earth interfaces and to make the data compatible with experimental data obtained during the weapons tests and information collected on the explosions over Japan, it was necessary to provide a means for elevating the reactor high above ground level.



Bare Reactor. For conducting the early 1962 portion of the BREN studies, the new Health Physics Research Reactor of Oak Ridge National Laboratory was used as a source of gamma rays and neutrons at the Nevada Test Site. The reactor is capable of operating as a steady state reactor and as a pulsing reactor. Photo shows the major components of the reactor. For steady-state measurements the reactor was stationed at elevations of 27, 170, 300, 500, 750, 1,125, and 1,500 feet above ground and was brought to delayed criticality 125 times on 54 operating days. In July, the reactor was returned to Oak Ridge and a 1,200-curie cobalt 60 gamma radiation source was installed in the BREN tower for continuation of the studies relating medical data with actual amounts of radiation.

Tower Experiments

A 1,527-foot steel tower was selected as the most effective device, and late in December 1961 construction of the tower was begun on Yucca Flat at the Nevada Test Site. The Oak Ridge National Laboratory's Health Physics Research Reactor was made available for use in the experiments pending completion of its permanent mounting facility at Oak Ridge. By the first week of March 1962, the tower was complete and the installation of the reactor in a hoist car began. The reactor was brought to criticality on March 21, 1962.

"Burst" operation. The Health Physics Research Reactor is capable of operating as a steady-state reactor and as a pulsing reactor. For the experiments both modes of operation were utilized. During the experiments, the reactor was brought to delayed criticality 125 times on 54 operating days for a total of 170.2 kilowatt hours. Between May 21 and May 28, the pulse or "burst" mode of operation was utilized for 11 bursts, the largest of which was 4.3×10^{16} fissions.

Steady-state measurements. In the course of the steady-state measurements, the reactor was stationed at seven elevations: 27, 170, 300, 500, 750, 1,125 and 1,500 feet above ground. Measurements were completed in June, and on June 30, 1962, the reactor was removed from the tower for return to Oak Ridge where it will be used in health physics studies.

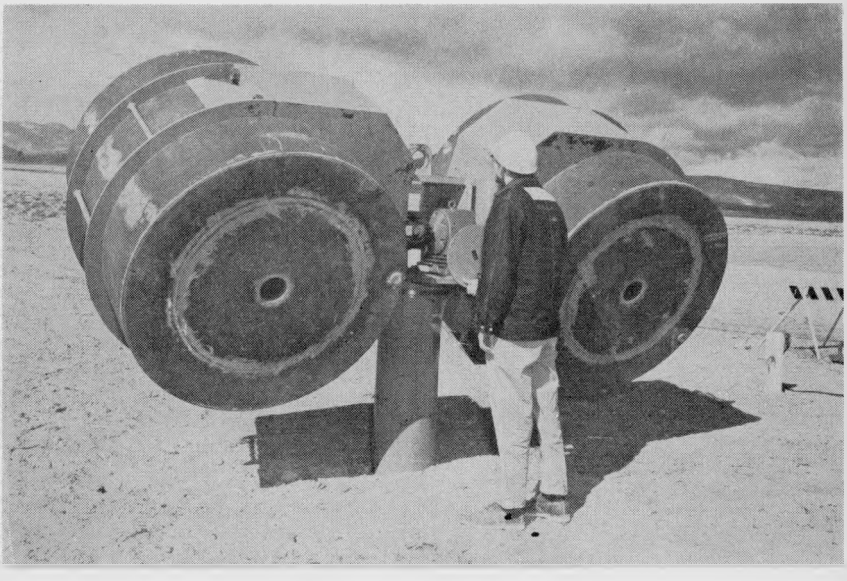
During the first week of July, a 1,200-curie cobalt 60 source was installed in the hoist car and used for a total of 90.9 exposure-hours over a period of about 2 weeks. Whereas the reactor is a source of mixed radiations, the cobalt 60 is a source of "hard" gamma radiations only.

Initial phase. Phase 1, "Spectra, Distribution and Attenuation of Mixed Radiation," represented the principal experimental effort of Operation BREN during 1962. In that program measurements were made with highly specialized laboratory instruments as distinguished from the more rugged instruments which must be used for experiments carried out at the time of nuclear detonations. Three facsimiles of Japanese houses were constructed on skids which permitted their being arranged in different attitudes with respect to the source of the radiations and at different distances from the tower. Measurements were made inside and outside the houses to provide data for determining the attenuation of neutron and gamma radiations. Using collimators the angular distribution of the radiations was measured to determine how much of the total radiation delivered at a point comes from the direction of the source relative to other horizontal and vertical angles. Because radiations are scattered by the air, the ground, and any structure in the path, it is necessary to know how much reaches the point

of interest from each direction in order to evaluate the shielding, or "scatter", afforded an individual by a building, such as a house.

The neutrons and gamma rays emitted by a reactor have a wide range of energies which are modified in the course of their transmission through air or matter. To obtain data on this effect, neutron and gamma ray spectral measurements were also obtained.





BREN Study Devices. The Japanese-style houses used in the Nevada Test Site studies relating medical histories of Hiroshima and Nagasaki atomic bomb survivors to known amounts of radiation were mounted on skids so that they could be removed to different positions around the BREN tower. Photo, *above*, shows two of the houses; in the foreground, cables to detection and other equipment is protected from vehicles by being placed above ground in wooden troughs. Photo *below* shows a pair of collimators used to measure the angular distribution of radiations to determine how much of the total radiation delivered at a point comes from the direction of the source relative to other horizontal and vertical angles.

Second phase. In October, the second phase of Operation BREN was initiated. A project, "Gamma-Ray Measurements, Spectra and Distribution," was undertaken to extend aerial radiometric studies performed previously at the Nevada Test Site in 1960. An extended source calibration area consisting of a number of precisely-arrayed, small, radioactive sources was laid out at the foot of the 1,527-foot tower. Measurements at a number of elevations were obtained with radiation detectors installed in the hoist car. The results will be compared with the 1960 data for use in further development of aerial radiometric equipment and the calibration of such equipment over a large uniformly contaminated area.

Other Experiments.

Several other experiments were pursued concurrently by groups having research interests separate from the principal objective of Operation BREN. Personnel from Oak Ridge National Laboratory (ORNL) in a project entitled, "Evaluation of Radiation Shields," made measurements which will permit the evaluation of the shielding characteristics of various metals and materials in a variety of configurations. The field work was an extension of a program of evaluation underway at ORNL. Scientists from Lawrence Radiation Laboratory, University of California, Berkeley, conducted a project entitled, "Neutron Field and Spectrum and Depth-Dose Studies." The U.S. Naval Radiological Defense Laboratory, San Francisco, Calif., under the project, "Neutron-Field and Induced-Activity Measurements," determined some of the characteristics of neutron distribution in soil and the induced radioactivity in samples of selected materials. The Armed Forces Radiobiology Research Institute conducted a project, "Comparative Dosimetry with Miniature Ionization Chambers," to obtain measurements which will be useful in the new program at the Institute's radiation exposure facility at Bethesda, Md.

NUCLEAR BOMB EFFECTS COMPUTER

To make a variety of data easily available to those interested in the effects of nuclear weapons, a circular slide rule [10] was designed utilizing data from the 1962 edition of "*The Effects of Nuclear Weapons*" which brought up to date the information of the 1957 edition.

[10] Available from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1. The 1962 edition of "The Effects of Nuclear Weapons," available as above, is priced at $3 and contains an envelope inside the back cover for those who desire to keep the slide rule and text together for handy reference.

Effects of Parameters

Twenty-eight effects of parameters can be quickly evaluated—13 relating to blast, 5 to thermal radiation, 1 to initial nuclear radiation, 2 to early fallout, 6 to crater and 1 to fireball dimensions. In addition, tabular data were included regarding: the reationship between overpressure and structural damage; probable biological effects of "fast"-rising "long"-duration overpressures; probabilities of penetration of soft tissue by glass fragments as a function of missile mass and velocity; probable biological effects of impact; and probable effects of exposure to various doses of ionizing and thermal radiation.

Most of the effects parameters were presented as a function of range and yield (1 kiloton to 20 megatons). However, simple extrapolation techniques make it possible to estimate most of the effects for yields greater than 20 megtons or smaller than 1 kiloton.

SECONDARY MISSILES

One of the major causes for casualties in a nuclear detonation is the flying debris—ranging from sticks and stones to heavy construction materials—caused by the blast pressure waves. The Commission has been conducting extensive research into the characteristics and production of such secondary missiles, especially as they might occur within shelters and houses.

Blast-Produced Missiles

As a result of studies made at the Nevada Test site, a weapons test report (WT–1468) entitled. "Secondary Missiles Generated by Nuclear-Produced Blast Waves," is now in preparation.[11] It contributes fundamental information covering production of flying fragments by blast, and contains quantitative data on over 17,500 missiles (stones, glass fragments, spheres, and other debris obtained during weapons tests at the Nevada Test Site). The missiles were recovered by special trapping techniques and weighed; other characteristics of the nuclear detonations were computed from the estimated yields of 11, 37, and 44 kilotons of three nuclear detonations during the 1957 Plumbbob weapon tests series. Through use of calibration data, the impact velocities were determined for secondary missiles arising in open areas, houses and in an underground shelter with an open entryway.

[11] The report will be available through the Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C., when published in early 1963.

Overpressure. The equivalent, ideal-wave [12] peak overpressures computed from measured blast data for the stations in the open varied from 3.8 to 21 pounds per square inch (psi). Two houses were located at the 3.8 psi and the underground shelter at 65 psi ranges. The effects of hill-and-dale terrain on the production of such missiles were investigated in one event.

Missile velocities measured at all stations, except the underground shelter, were compared with those computed from a prediction model based on an ideal blast wave. An analytical procedure was presented for estimating the translational velocities imparted to men using the measured velocities of spheres and stones.

Lethal effect. The data obtained inside the underground shelter with an open, but complex entryway have a special significance because steel-sphere missiles, having approximately the same acceleration coefficient as man, were employed. The spheres—initially placed at various distances from the end wall of the shelter—were impacted against the latter at velocities ranging from 45 to 159 feet per second (31 to 108 miles/hour), well above those estimated to be fatal for man. On the other hand, the shelter was subjected to a "free-field" overpressure of about 65 psi (700 feet from an estimated airburst of 38 kilotons) but it remained intact. Thus, these data dramatically show the potential dangers to occupants of open shelters due to displacement by blast winds which enter the structure when the pulse of overpressure passes the entryway.

NEW BIOMEDICAL RESEARCH FACILITIES

Fission Product Inhalation Laboratories

The Fission Product Inhalation Project, initiated in June 1960 by a contract between the Division of Biology and Medicine and the Lovelace Foundation for Medical Education and Research of Albuquerque, N. Mex., moved into the early actual research stages during the spring of 1962. Space at the Foundation headquarters is now occupied by the Aerosol, Biochemistry, Health Physics and Total Body Counting Laboratories, plus the technical supportive groups. At an interim field site on South Sandia Base, the Radiobiology Laboratories were established wherein controlled inhalation exposure of animals is undertaken; the body distribution and excretion of radioactive materials are determined; and physiological studies are

[12] The term "ideal-wage refers to overpressures that occur almost instantaneously as against the "nonideal-wave" where the overpressure builds up relatively slowly; the "nonideal-wave" occurs more often than the "ideal-wave" after a nuclear detonation.

carried out; temporary facilities for holding large and small animals were also established at the field site. A contract was awarded by the Albuquerque Operations Office in May 1962, for Phase I of the permanent construction which is to be completed within 1 year.

Interim operations have included studies of techniques of aerosol preparation, aerosol sampling, electron microscopy and particle size measurements. Waste disposal studies have been undertaken to avoid any major contamination problems. The Radiobiology Section has initiated personnel training and exposure of small animals to aerosols containing low levels of cesium 137. Thus far, two species have been studied and other experiments are underway to establish the exposure dose likely to produce fairly acute radiation effects. The Biomedical Section has established a battery of over 30 biochemical tests selected to survey body organ and system functions. Techniques for microbiology and pathology studies also are being developed.

To guide the initial buildup of the work, priority assignments have been given to studies of aerosol physics, radiobiology, and biology and medicine in the order named. As the program advances, radiation exposure via the inhalation route and the biological effects therefrom will be brought under systematic study in areas of research never before attempted.

Animal Bioradiological Laboratory

The first increment of the new Animal Bioradiological Laboratory was completed, equipped, and occupied at Lawrence Radiation Laboratory in Berkeley, Calif., during the year.

The new building cost approximately $500,000, and contains 13,177 square feet, gross. The structure has novel design features and equipment for fundamental studies of the biological effects of radiation.

Disease-free Animals. One feature is a laboratory for breeding and maintaining a colony of mice and rats free of parasites and infectious diseases commonly occurring in these laboratory animals. Breeding stock for the colony are animals taken by Cesarean section, and nursed by disease-free foster mothers from a colony at the University of Notre Dame. The environmental conditions of the facility—air, temperature, and humidity—are carefully controlled and extensive additional measures, including a system of barriers to infection, have been established. Such animals are highly desirable to prevent confusion of effects from radiation with effects of disease. It has already been established that such pathogen-free animals make better recoveries from a near lethal radiation dose.

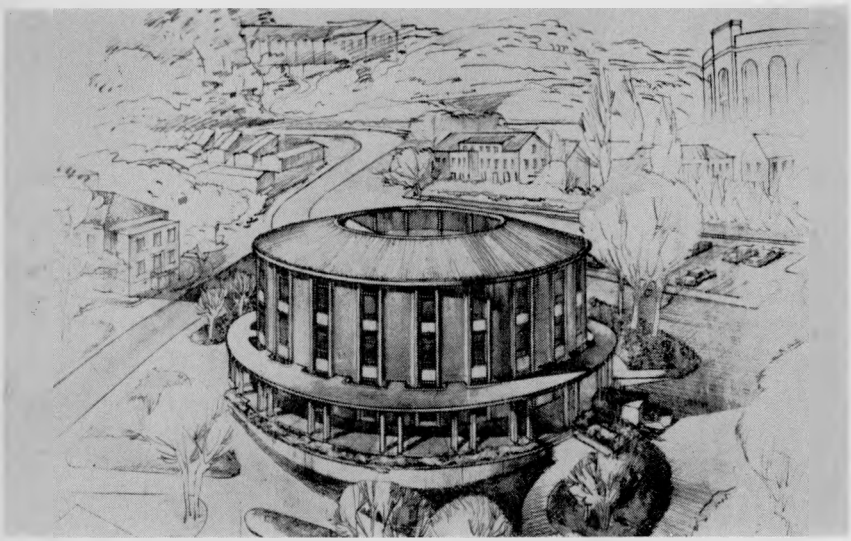
When a usable colony of some 10,000 animals is built up during 1963, they will be used initially in an effort to detect radiation effects

from dosages in the range of 2 to 10 roentgens (*r*). Little experimental data are available below the level of 100 *r*.

150–1,500 roentgen range. A novel feature will be the cobalt installation. It will consist of two integrated cobalt sources—a very large one giving 1,500 *r* per hour at 1 meter and a second giving 150 *r* per hour at 1 meter. One of a wide range of problems to be studied with this machine will be the differences in biological effect from the same dose given over different periods of time. Acute and late effects will be studied as a function of dosage rates.

Chemical Biodynamics Laboratory

Construction was started in April at the University of California on the Chemical Biodynamics Laboratory, to house the Bio-Organic Group of the Lawrence Radiation Laboratory.



Biodynamics Laboratory. Artist's concept of the new Chemical Biodynamics Laboratory at the University of California Lawrence Radiation Laboratory, Berkeley. The structure, being built at a cost of $1,470,000, will provide 36,500 square feet (gross) of space for the Bio-Organic Group. Diameter of the structure, built to fit the needs of the interdisciplinary group, is 116-feet. The circular design will focus the activities of the group from small "private" working areas around the periphery to larger "public" areas in the center. In effect, the design will provide a "built in" interaction among the scientists deemed essential for success in the group's principally AEC-financed research effort in such areas as photosynthesis, radiation chemistry, chemical evolution, and other problems of molecular biology. Funds for the construction, however, are being provided by the University, Kettering Foundation, the National Science Foundation, and the National Institutes of Health.

The research program—dealing with photosynthesis, radiation chemistry, chemical evolution, and other problems of molecular biology—is supported largely by the Atomic Energy Commission. However, the new structure is being financed by the Kettering Foundation, University funds, the National Science Foundation, and the National Institutes of Health, at a total cost of $1,470,000. No AEC funds will be used in the construction, but they will be used for equipment and support of research work.

The novel, 36,500 square foot (gross) structure, scheduled for completion in the fall of 1963, will increase collaboration and efficiency in research being conducted for the Commission by various groups scattered about the campus.

Animal Quarters at Argonne

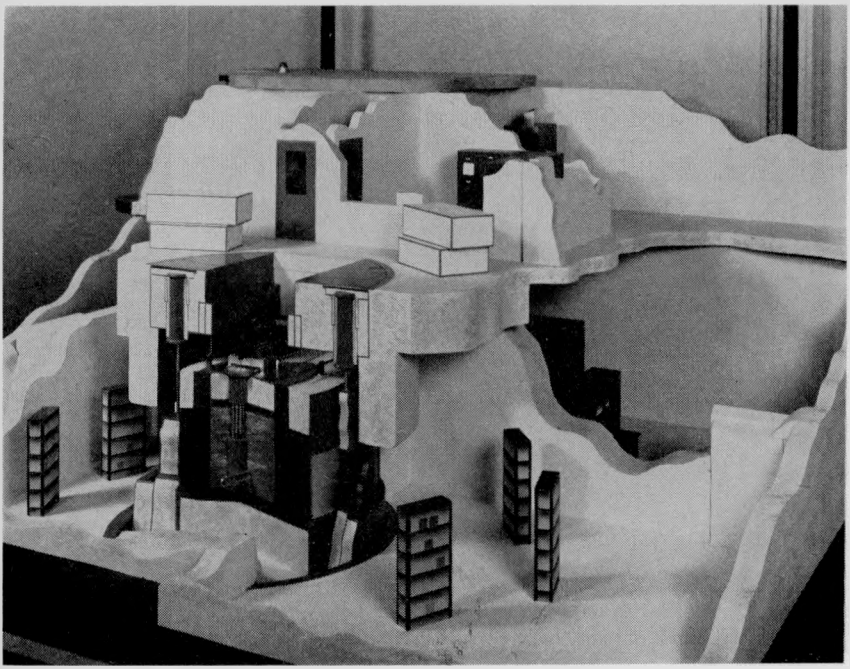
A new animal quarters addition to the biology building at Argonne National Laboratory was completed during June. This addition, which can house 130,000 mice, was constructed to support animal research programs including a large-scale statistical experiment using mice to determine the effects of ionizing radiations taken internally in food, or by injection.

The addition consists of 3 offices, 5 laboratories, 7 rooms where nonradioactive animals can be kept, 12 rooms for housing radioactive animals, a room for preparing radioactive foods, a room for injecting radioactive compounds, and a room for raising grasshoppers to be used in connection with radiation experiments. The basement area under the animal rooms contains a stock room and facilities for washing animal cages. The addition cost $904,000, including $100,000 for scientific equipment and facilities for animal care.

JANUS, Biology Reactor for Neutron Irradiation Studies

At the end of 1962, construction of Janus, the first nuclear reactor designed solely for biological research, was completed at the Argonne National Laboratory. Following criticality and instrumentation and dosimetry studies, the reactor is expected to play an important part in neutron toxicity studies, particularly with long-term exposures of small laboratory animals.

Double-faced exposure areas. Janus is a conventional, heterogeneous tank-type reactor with enriched uranium fuel elements, designed to provide large neutron-exposure areas from two faces (hence its name, Janus). One of the faces will provide high dose rates of fast



"*Janus*" *Reactor.* First nuclear reactor designed solely for biological research, the Janus is a conventional, heterogeneous tank-type reactor with enriched uranium fuel elements that can provide large neutron exposure areas from two faces (hence its name). The facility was completed during the past year at Argonne National Laboratory. The scale model shows the two irradiation faces which can provide neutron exposure to two rooms. In the small high-dose room (at far *left*) dose rates of fast neutrons—up to approximately 150 rads per minute at an operating level of 200 kilowatts—can be provided for acute exposures. The other face will provide a range of low dose rates up to approximately one rad per hour for chronic exposures in the large room on *right*.

neutrons (up to approximately 150 rads/min., at an operating level of 200 kilowatts) in a small room for acute exposures; the other face will provide a range of low dose rates up to approximately 1 rad/hr. in a large room for chronic exposures. The reactor is expected to operate 16 hours a day for at least 3 years without fuel change. A neutron activation tube close to the core will permit preparation of short-lived radioisotopes. The reactor was constructed at a cost of $480,000. The entire Janus facility, including an annex to the Argonne biology building to house the reactor, cost $715,000.

Problem areas. Research with Janus will be centered, essentially, on three problems: (*a*) differences in time and cause of death following neutron and gamma irradiation, (*b*) deviations in additivity of neutron and gamma radiations in causing death, and (*c*) differences in

recovery rates following neutron and gamma irradiation. All phases of the work will be conducted to yield a coherent picture of the response of the mouse, as a representative animal, to ionizing radiations as a part of its environment and as an imposed burden. These data are considered to be an indispensable step toward the final goal, a valid foundation for projection of the results to other species, and eventually to man.

PHYSICAL RESEARCH

The basic physical research program of the Atomic Energy Commission is representative of all the fundamental atomic energy research conducted in the United States. There are four major areas of endeavor: physics and mathematics, chemistry, metallurgy and materials, and controlled thermonuclear research. Investigations are carried out by scientists working in the Commission's major laboratories, colleges and universities, and other private laboratories including industrial and research organizations. Results of such investigations are reported in the special Commission research report supplemental to this Annual Report.[13] This portion of the Commission's Annual Report concerns itself with some of the more important new research facilities, recently completed or now under construction or improvement with AEC financial assistance, that play an important and vital role in the basic physical research program.

NEW PHYSICAL RESEARCH FACILITIES

During the past year, six new significant research particle accelerators—"atom smashers"—were completed. Also completed and now in operation are two new controlled fusion research facilities—the DCX–2 at Oak Ridge National Laboratory, and the ALICE magnetic mirror device at Lawrence Radiation Laboratory, Livermore, Calif.[14]

Princeton-Pennsylvania Proton Accelerator

Assembly of components for the 3.0 billion electron volt (Bev) Princeton-Pennsylvania Proton Accelerator, located at the James

[13] "Fundamental Nuclear Energy Research—1962," available from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

[14] See "Fundamental Nuclear Energy Research—1962."

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Forrestal Research Center, Princeton University, was completed early in June 1962, at a cost of $11.6 million. One of the unique features of this machine is its ability to supply bursts (pulses) of protons 19 times per second, which is approximately 100 times greater than the frequencies achieved by other accelerators of the same type.

The facility, which took about 5 years to build, will be used by scientists from Princeton and Pennsylvania Universities, and by interested physicists from other institutions in the area. A fast-cycling 15-inch bubble chamber is being assembled as a major tool for research with the particle beams to be obtained from the accelerator.

On June 20, 1962, injection (5 turns per pulse) was successfully accomplished and the beam was accelerated by the radiofrequency system for an additional 30–40 turns until it was lost because of incomplete adjustment of the frequency program. Following this test, the accelerator was shut down, for a period of approximately six months, to permit necessary repairs to the large choke that serves as an essential component in the power supply system for the accelerator magnet. Since plans are being made for future extraction of a proton beam with the new accelerator, construction of an external proton beam building to accommodate experiments with this beam will commence in the spring of 1963. The total estimated cost for the additions to this machine will be approximately $10.8 million.

Cambridge Electron Accelerator

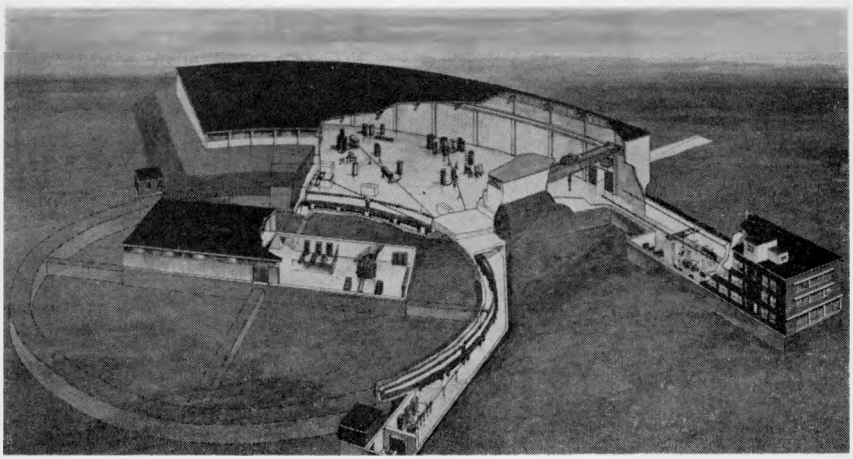
The $12 million Cambridge Electron Accelerator (CEA), located on the Harvard University campus, Cambridge, Mass., was completed in March 1962. The accelerator is operated jointly by Harvard University and the Massachusetts Institute of Technology (MIT), and will also be made available to qualified physicists from other neighboring institutions who are interested in the use of this unique research facility. An electron beam was first accelerated with the CEA to an energy of 2.2 Bev on March 7, 1962, and on the evening of August 13, 1962, the design energy of 6.0 Bev was successfully attained.

The facility is unique in that, at the present time, it provides a source of electrons, or of short wavelength X-radiation, of exceptionally high energy and approximately five times greater than any other electron machine presently operating in the world. The repetition rate of the acceleration process is expected to make possible the attainment of very satisfactory intensities of these radiations for high energy research. Electrons are particularly well suited for the conduct of many experiments, since their basic electromagnetic interaction with

target nucleons and electrons is free of complications which arise in experiments with "strong-interacting" particles. In particular, electrons of the high energy attainable with this accelerator will provide an exceptionally sharp probe with which to examine the details of nucleon structure.



Cambridge Electron Accelerator. Located on the Harvard University campus, the new $12 million Cambridge Electron Accelerator will be used jointly by Harvard and Massachusetts Institute of Technology and will also be made available to other institutions. The facility provides a source of electrons of exceptionally high energy—approximately five times greater than any other electron accelerator presently operating in the world. Photo *above* shows the exterior of the accelerator and the drawing *below* shows the main features. In the foreground is the equipment used to inject an electron into the circular, earth-covered accelerator. At the *top* of the drawing, beam tubes for withdrawing electrons from the accelerator for high energy physics experiments are shown, and on the *right* is the shop where experimental devices will be fabricated.



88-Inch Cyclotron

The new 88-inch spiral ridge cyclotron at the Lawrence Radiation Laboratory (Berkeley)[15] was completed during 1962.

When the $4.85 million machine is in full operation, its maximum acceleration of particles will be: protons to 55 million electron volts (Mev); deuterons to 65 Mev; alpha particles to 130 Mev; and heavier nuclei, such as carbon 12 and oxygen 16, to energies of 32 Mev per nucleon. The energy of its beams can be varied continuously from a low range up to the maximum of energy.

The new cyclotron, which took a little over 4 years to build, makes possible more accurate scattering experiments in the energy ranges it covers. The research program includes atomic beam research, nuclear spectroscopy, and the exploration of the biological effects of radiation. It can make copious quantities of selected isotopes, some of which have not been available or which were available only in minute quantity.

Good progress was made in debugging the various components. The radiofrequency system ran reliably at full power. The essential problems in developing a reliable and flexible beam deflecting system were solved.

The extracted alpha particle beam at 65 Mev showed excellent optical qualities; for example, after bending through a 57 degree angle, the energy spread was found to be small (0.2 percent) and the beam could be focused onto a very small area some 40 feet from the cyclotron.

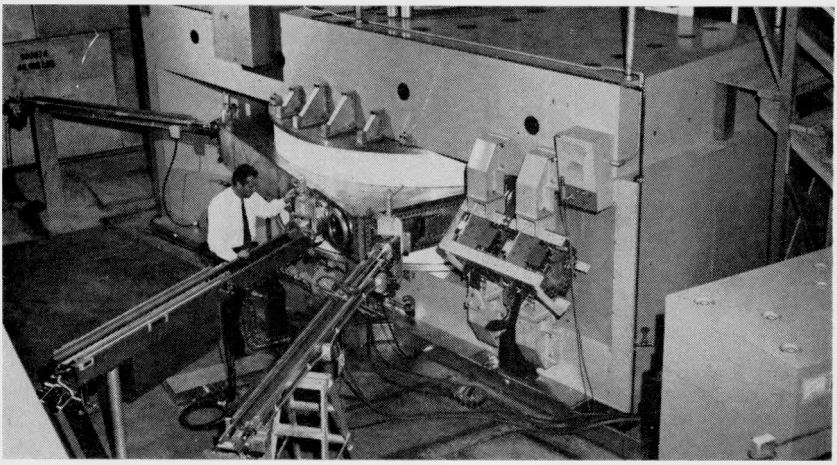
The external cave facilities—three for large experimental setups, and one with remote handling equipment for isotopes production—were nearing completion at year's end.

60-inch cyclotron shutdown. An important phase of nuclear history was marked with the shutdown and dismantling of the 60-inch cyclotron at Lawrence Radiation Laboratory (Berkeley) which is being replaced by the new 88-inch cyclotron. The 60-inch machine began operation in June, 1939, and had completed 23 years of historic work, during which it was used for many important discoveries.

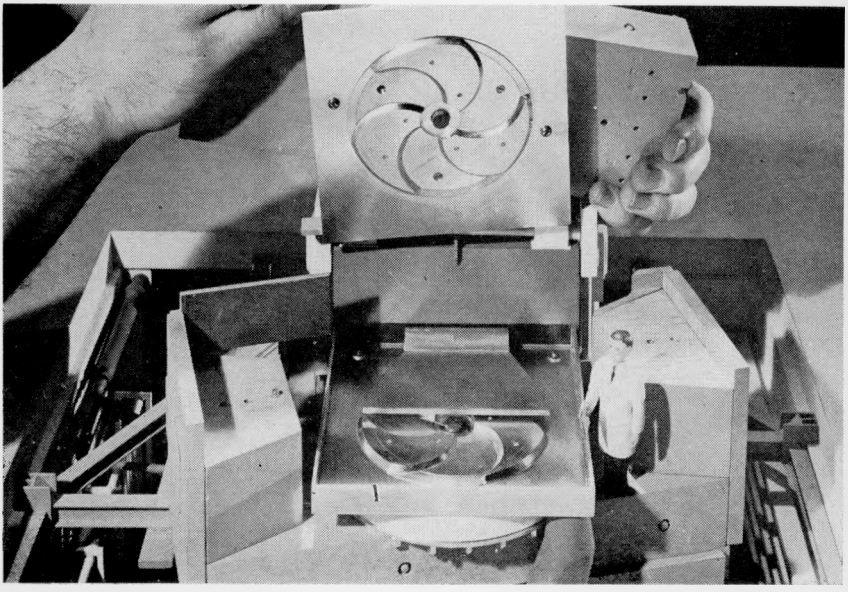
The instrument was constructed with private funds donated to the University of California. After the establishment of the Atomic Energy Commission, most of the support for the cyclotron's operation came from Commission funds.

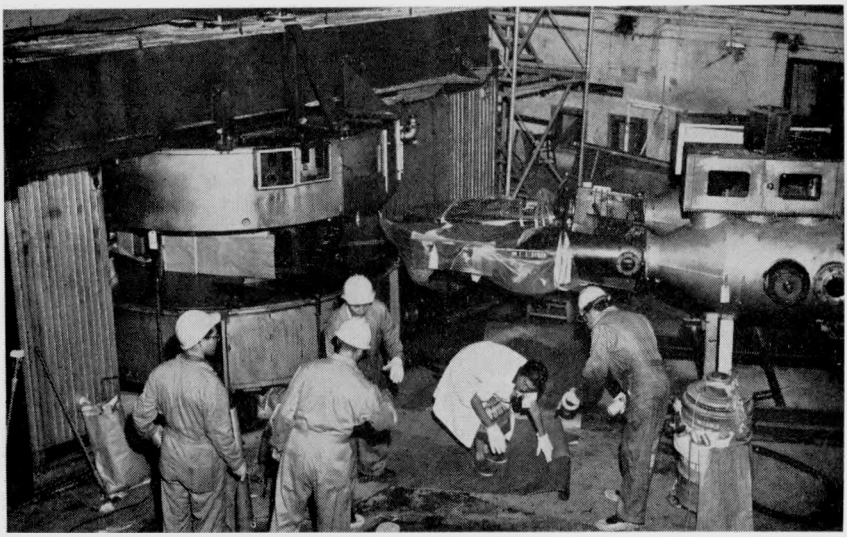
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[15] The Lawrence Radiation Laboratory, which is contract-operated for the Commission by the University of California has facilities at Livermore, Calif., as well as on the University's Berkeley campus. The Livermore facilities are primarily concerned with research and development on matters associated with nuclear explosives, and research on thermonuclear (fusion) reactors. While some thermonuclear work is also done at the Berkeley facilities, most of the effort at this site is in the life sciences, physics, and chemistry fundamental research areas. Throughout this report, Berkeley or Livermore is parenthesized to indicate at which of the Lawrence Radiation Laboratory sites the work mentioned is being done.



New 88-inch Cyclotron. This early 1962 photo, above, shows the 88-inch spiral ridge cyclotron, which was completed during the year. The accelerator was constructed with Commission funds as a part of the fundamental research program at the University of California Lawrence Radiation Laboratory, Berkeley. The design of the cyclotron gives it a beam with higher intensity and flexibility than other types of cyclotrons. The energy of the beams can be varied up to a maximum of 60 Mev for protons, 60 Mev for deuterons and 120 Mev for alpha particles. The instrument will allow scientists to work in previously inaccessible intermediate energy ranges, permitting new experiments on the atomic nucleus. The white, circular objects at the center are copper coils of the 300-ton electromagnet. Between the coils is the accelerating chamber. Photo, *below*, is of a cut-away scale model and shows the raised plateaus of the 300-ton electromagnet's pole faces, three in number and radiating like the arms of a starfish, which are responsible for the designation, spiral ridge cyclotron. The ridges are important in allowing the machine to accelerate beams to higher energies than conventional cyclotrons, and in greater intensity than frequency modulated cyclotrons.





On the Move. Photograph shows the dismantling of the 60-inch cyclotron at the Lawrence Radiation Laboratory, Berkeley. The machine completed 23 years of historic service on June 30, 1962, and the magnet was removed to the Davis Campus of the University of California for conversion to a 72-inch spiral ridge cyclotron. In the photograph, the dees have been pulled out of the magnet, and covered with plastic as a part of radiation safety measures. The old machine has been replaced by the new 88-inch spiral ridge cyclotron at the Berkeley site.

Seven new elements were discovered with the 60-inch cyclotron: 85 (astatine), 93 (neptunium), 94 (plutonium), 96 (curium), 97 (berkelium), 98 (californium), and 101 (mendeleevium). The plutonium discovery helped stimulate the development of the nuclear weapon, and microscopic quantities of the element produced in the 60-inch machine were used in the development of the chemical separation process for Hanford.

Scores of radioisotopes were also discovered—for example, carbon 14, hydrogen 3 (tritium), helium 3, and uranium 233. The machine also produced the first radioisotopes in sufficient quantities for their early exploration in biology and medicine, agriculture, and physical science research.

High energy heavy particle beams were explored significantly in therapy and in radiobiology studies.

Upon shutdown, the 60-inch cyclotron was dismantled, and the magnet was transferred to the Davis campus of the University. There it will be used in a 72-inch spiral ridge machine which will be central to the development of a nuclear physics program on that campus.

ANL Tandem Van de Graaff

The new $2,500,000 Tandem Van de Graaff Accelerator facility at Argonne National Laboratory was completed in May 1962. In early experiments with this machine, protons, deuterons, and both singly- and doubly-charged helium ions have been accelerated. Energies as high as 13.3 Mev have been obtained (design specifications called for 12 Mev energies). The accelerator has been employed in studies of the angular distribution of elastically scattered protons from nickel and copper isotopes. The protons are scattered from self-supporting foils of nickel 58, nickel 60, copper 63, and copper 65. Also, it has been used in studies of elastic deuteron scattering and (d, p) reactions in calcium 40. It is now being employed in a comprehensive study of the gamma rays from proton reactions, especially proton capture, in light nuclei.

ORNL Tandem Van de Graaff Accelerator

Installation of the new $2,400,000 Tandem Van de Graaff Accelerator facility at Oak Ridge National Laboratory was completed in early 1962. Protons have been accelerated to energies up to 13.6 Mev, 1.6 Mev above specifications. In addition to protons, oxygen ions have been stripped to multiple charged states and accelerated to energies up to 42 Mev, with beam currents up to one microampere. A recent discovery is that the carbon 12 (oxygen 16, alpha) magnesium 24 reaction exhibits rapid fluctations in the alpha-particle group yields as a function of small (50 Kev) changes in bombarding energy in the 20 to 22 Mev energy range. These fluctuations may be associated with variations in the level density of certain very highly excited states of silicon 28. The use of high resolution in this energy range is apparently revealing fine structure at very high excitation of the compound state.

A $1 million Tandem Van de Graaff, paid for by the AEC and similar to the new Argonne and Oak Ridge accelerators, was provided for a facility being constructed by Rice University.

The Oak Ridge Isochronous Cyclotron

The preliminary stage of test operation of the new $3.7 million Oak Ridge Isochronous Cyclotron (ORIC), at Oak Ridge National Laboratory, has been completed. The first proton beam at full radius was obtained on March 19, 1962.

The machine was operated initially with a limited radiofrequency power supply at a fixed frequency of 7.79 megacycles. With resonance at a magnetic field strength of 5.1 kilogauss this gave an 8 Mev

proton beam. Extensive tests were made at this energy to confirm the validity of the design, the extensive computer calculations, and the unique construction. A constant orbit frequency (isochronism) is possible with ORIC because the average magnetic field has been designed to increase with the radius. Isochronous acceleration of protons to maximum radius is achieved with a very low voltage on the radiofrequency system. The ions can be held in phase for at least 400 orbits.

With the installation of the final stage of the power amplifier in the radiofrequency system, the maximum energy will be increased to 75 Mev for protons, and to comparable higher energies for heavier ions. The magnetic field and the radiofrequency can be readily adjusted for the fixed-frequency acceleration of any ion with an energy/mass ratio of from 1/1 to 1/8. ORIC, with its high beam intensity and flexibility, will permit study in the energy region from 20 to 100 Mev which has previously been largely unexplored for lack of a machine with the necessary characteristics.

Annex to Physics Building

The Physics Building Annex, costing approximately $2,000,000, was completed and occupied at the Lawrence Radiation Laboratory (Berkeley) during late 1962. The Annex adds 61,000 square feet, gross, to the present physics facilities which were completed more than a decade ago.

The new facility was made necessary by expansion of the Commission's physical research program. A major factor has been the evolution of new research techniques since the Bevatron accelerator went into operation in 1954; for example, the development of data reduction and computer methods for the exploration of more sophisticated problems and the handling of much larger amounts of new information in high energy physics.

Completion of this building makes it possible to house in one location all of the previously scattered physics research group. The establishment of a computer center, including installation of a 7090 machine, was effected and a small enlargement of the library was also possible.

184-inch Cyclotron Building Expansion

The expansion of the research area of the 184-inch cyclotron building at Lawrence Radiation Laboratory (Berkeley) was completed.

The addition, costing $500,000, adds 8,400 square feet, gross, to the research area. The new space provides greater flexibility, makes available duplicate target areas to which the beam can be alternately directed and opens the way to more elaborate experiments.

FACILITIES UNDER CONSTRUCTION

During 1962, the Commission had a number of major physical research facilities under construction. Among these are two new high energy particle accelerators, a high flux research reactor, and a novel computer. Also significant are plans to procure two new Van de Graaff accelerators expected to have unprecedented utility in low energy physics research. (Two major facilities now under construction and which will be used in the transplutonium production program—the High Flux Isotope Reactor (HFIR) and the transplutonium processing plant (TRU) both at Oak Ridge National Laboratory—are described in detail in the supplemental report "Fundamental Nuclear Energy Research—1962".)

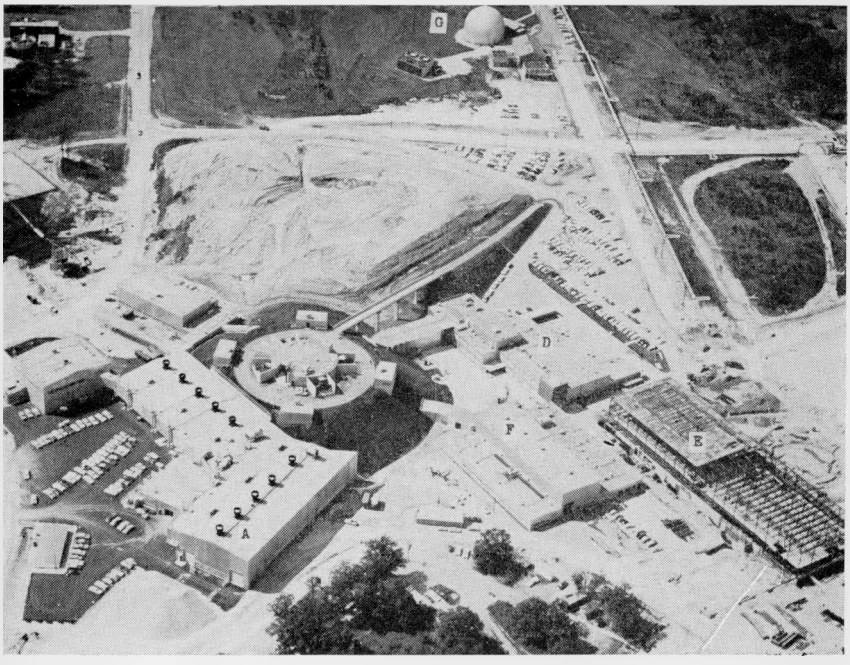
Zero Gradient Synchroton

Construction is approximately 75 percent complete on the 12.5 Bev Zero Gradient Synchrotron (ZGS) at the Argonne National Laboratory, and it is expected that the approximately $47 million facility will be completed during 1963. Difficulties in fabrication of the 128 magnet blocks which constitute the main ring of this accelerator has been the major delay in completion of the accelerator from its previously scheduled date of mid-1962. By the incorporation of recent techniques in the design of the ion source, a high intensity beam of well-focused protons has been obtained from the pre-injector of the linear accelerator which will serve to inject particles into the ZGS when it is completed. It is planned by the Argonne staff to make the accelerator facility available on a round-the-clock schedule to the many research groups in the Midwest area for high energy physics experiments. A high energy physics building is being constructed at ANL to implement the conduct of this program.

Stanford Linear Electron Accelerator

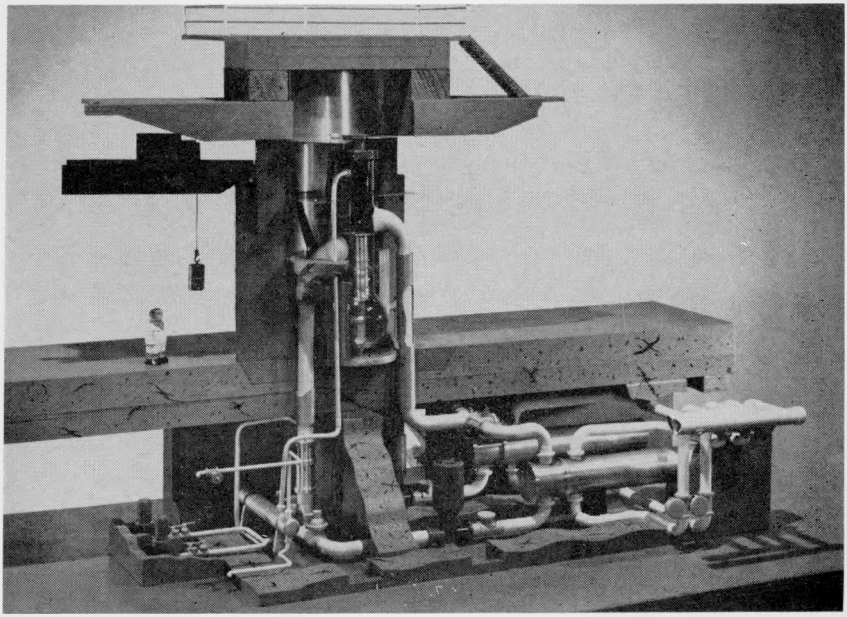
A contract for the construction of the Stanford Linear Accelerator was awarded to Stanford University by the Atomic Energy Commission on April 30, 1962. Construction of the 2-mile-long linear electron accelerator, designed to reach an energy of 20 Bev if supplied with a peak radiofrequency power of 24 Mev from each of 240 S-band klystron tubes, started in July. It is expected to cost some $114 million by the time it is completed in mid-1966.

Electrons will be accelerated by the powerful klystron tubes through a 10,000-foot pipe buried 25 feet underground and smash

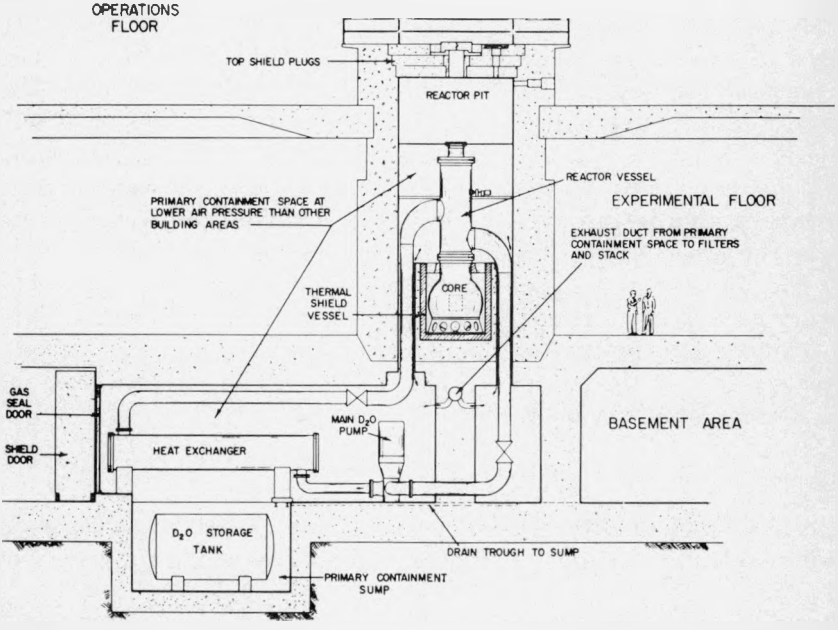


Zero Gradient Synchroton. At year's end, the 12.5 billion electron volt Zero Gradient Synchrotron (ZGS) at Argonne National Laboratory was about 75 percent complete. It is expected to be in operation by late 1963. This aerial photo, made in September 1962, shows the major buildings of the ZGS complex. The circular accelerator (*center* of photo) is partially covered by earth. Experiments with proton particles will be conducted in the building in the foreground ("*A*") and meson particle research will be done in "*B*". The bubble chamber building is indicated by "*C*". Building "*D*" will house the accelerator controls, administrative offices, and laboratories, and the high energy physics building is indicated by "*E*". "*F*" is the shop and assembly building. Adjacent (at "*G*") to the ZGS complex is the 5,000 ekw Experimental Boiling Water Reactor (EBWR) which was put in operation in 1956.

into nuclear targets with energies of 10–20 Bev. If desired, this energy can be doubled later by adding more klystrons. Designed to operate at a repetition rate of 360 cycles per second, the accelerator will provide an electron beam of exceptionally high energy and intensity for research on electron-induced reactions, study of particle structure, and the production of secondary beams which themselves will be highly useful for elementary particle research. The facility will also serve as a national center for research in high energy physics when completed. A staff of 750, including 40 senior scientists, will operate the center. Physicists from all over the world will participate in the center's particle physics research program.



New Research Reactor. Photo, *above*, is a model of the High Flux Beam Research Reactor (HFBR) currently under construction at Brookhaven National Laboratory. The HFBR will be housed in a three-level tank-type building. Neutron beam experiments will occupy the entire main floor of the building. The auxiliary machinery for the reactor complex and a canal for spent fuel elements will be in the basement. The reactor will be operated from the upper, or operations, floor. Cutaway diagram of the High Flux Beam Reactor, *below*, shows the arrangement of the three floor levels, and the shielding walls and flooring.



High Flux Beam Reactor

The High Flux Beam Reactor (HFBR) now under construction at Brookhaven National Laboratory is expected to be completed by end of 1963. This new research reactor will produce a neutron flux nearly 100 times greater than that of the Brookhaven Graphite Research Reactor, with only a twofold increase in power.

The essential feature of the $11,850,000 HFBR will be its compact, undermoderated core operating at high power density in heavy water. The core is formed of plate-type aluminum elements fueled with enriched uranium. The heavy water surrounding the core serves both as coolant and moderator. The high epithermal neutron flux is thermalized in the reflector. The normal thermal power of the HFBR will be 40 megawatts. Measurements taken at a critical experiment indicate a peak flux of thermal neutrons of 7×10^{14} neutrons per square centimeter per second (cm^2/sec). The maximum total epithermal flux, occurring in the core, will be about 1.6×10^{15} neutrons per cm^2 per sec. There are nine horizontal beam tubes in the reflector, with two of these arranged to bring out double beams.

The HFBR has been designed to provide neutron beams for a variety of research programs. As experimental techniques have improved, increasing need has arisen for higher fluxes. In general, as the neutron beams are intensified, greater resolution can be achieved in a given experiment, and more sophisticated experiments become possible. Among the experiments that require more intense beams are resonance measurements with fast choppers, diffraction studies on complicated structures, low temperature neutron alignment, measurements using polarized neutrons, and a series of solid state problems involving the low-lying excitation levels in solids. In most of these experiments, the magnitude of the fast neutron component of the beam is critical, since the fast neutrons (in the Mev energy range) scatter in the experimental apparatus and its shielding and become a source of background neutrons. The design problem for the HFBR thus had two aspects: first to develop external beams of high intensity in the low energy region, and second, to reduce the fast neutron component in these beams to a minimum.

The HFBR will be housed in a three-level tank-type building. The neutron beam experiments will occupy the main floor. The auxiliary machinery for the reactor complex and a canal for spent fuel elements will be in the basement. The reactor will be operated from the upper, or operations, floor.

Illinois Computer Project

A very high speed electronic digital computer of novel design is being built in the Digital Computer Laboratory of the University of

Illinois under the joint support of the Atomic Energy Commission and the Office of Naval Research.

Novel features of the computer include the organization of the high speed memory on the "word-select" rather than on the conventional "coincident-current" principle, the achieving of high speed arithmetical operations by such means as carry completion sensing and the deferred assimilation of carries. The device will have a "look ahead" feature in the control so that, concurrently with the execution of an instruction under the guidance of the "arithmetic control," preparations will be made by the "advanced control" for the execution of the next instruction. Logical design of this degree of competence, plus very good high speed circuitry, will result in a very fast computer. The machine also has the highly desirable feature of a comparatively long word-length, which will make it possible to avoid time-consuming double-precision operations in the many cases where this must be done when conventional commercial equipment is used at a considerable cost in computing speed. Many features of the new computer's logical design are being incorporated in machines built for commercial use.

Emperor Tandem Van de Graaff Accelerators

The Commission, in December 1962, signed a contract for the purchase of two 20 Mev "Emperor" Tandem Van de Graaff accelerators to be delivered in 1965. These machines are the first of a kind and represent the latest and most advanced model of a long series of Van de Graaff accelerators of ever increasing beam energy and intensity. The machines will cost $3 million each, as against the $1 million each for the Tandem accelerators installed at Argonne, Oak Ridge, and Rice, and their beam energies will be double the strength of these three accelerators.

It is planned that one of the machines will be installed at the University of Minnesota and the other at Yale University.

FACILITY IMPROVEMENT

Further development and refinement of existing accelerators continue to be a vital part of the basic physical research program. In addition to the large-scale Bevatron improvement program presently under way at Lawrence Radiation Laboratory (Berkeley), modifications were recently completed to the 3 Bev Cosmotron at Brookhaven National Laboratory and have led to considerably improved operation of this heavily used facility. The more recently completed Alternating Gradient Synchrotron at Brookhaven, which already has

led to the significant anti-xi-minus and neutrino results,[16] is being brought to fuller effectiveness as a research tool by the provision of ancillary beam-handling devices and by work directed to obtaining an extracted proton beam. A new large bubble chamber building is nearing completion and will greatly enhance the utility of this outstanding accelerator.

Productive research continues with smaller accelerators operated in university laboratories, and active consideration is being given to the possible advances which may be made on the basis of the experience and theoretical understanding recently acquired in the field of accelerator technology. Application of existing accelerators has also been made, and continues to be made, to research of biomedical interest, to the study of radiation damage effects, and to radiation problems which arise in manned or unmanned space missions.

The industrial implications of advances in accelerator technology is illustrated by the recent commercial interest in the manufacture of high-duty cycle betatrons which employ fixed-field alternating gradient principles developed by the staff of the Midwestern Universities Research Association under Commission contract.

Bevatron Improvement Program

A 3-year program of remodeling the Bevatron (6.2 Bev), at a cost of $9.6 million, is under way at the Lawrence Radiation Laboratory (Berkeley). The Bevatron has been shut down since June 21, 1962, for major modifications and is expected to be back in operation during February 1963. The overall modification work will take until mid 1964. Built in 1954, the Bevatron has played a leading role in the Commission's high energy physics program.

The general objectives of the extensive modifications are to gather information more rapidly, to do more elaborate experiments, and to simplify many research problems.

Beam intensity increase. These objectives will be achieved by increasing the intensity of the 6.2 Bev proton beam by a factor of ten or more, deflecting the beam out of the chamber for the first time, and installation of more sophisticated electronic controls.

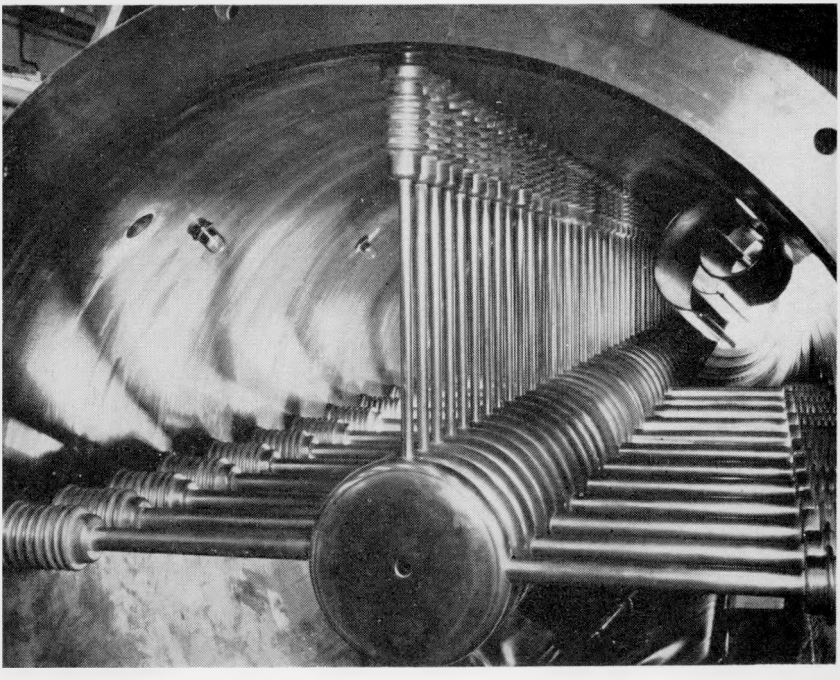
A major step in increasing the intensity of the beam has been the successful development of a new injection system. The heart of this system is a new proton linear accelerator, which has been completed, tested, and installed. The 40-foot machine incorporates the design features of a proton linear accelerator developed at Berkeley shortly after World War II, and additionally utilizes strong-focusing in its drift tubes. The injector has achieved its design capability—an in-

[16] See "Fundamental Nuclear Energy Research—1962."

tense, 50 milliampere beam for injection into the Bevatron at approximately 20 Mev.

Major components of the beam extraction system were tested successfully. A new radiofrequency accelerating system, new instrumentation to monitor and control beam intensity and position and the magnetic field will implement the flexibility and efficiency of the machine.

The modifications will permit "flat-topping" the magnetic field, making it possible to use the larger number of particles in each pulse for a half second (10 times longer than before), with minimum variation in particle energy.



Accelerator Interior. Photo shows the interior of the 20 million electron volt, 40-foot proton linear accelerator installed during the year as a part of the $9.6 million, four-year Bevatron improvement program at Lawrence Radiation Laboratory (Berkeley). The view is from the input end, showing the drift tubes each of which is a magnet which sequentially "pulls" and then "pushes" the individual protons to increase the particle's speed. The particle beam passes through the small hole in the center of the "lollypops". The three-way supports provide rigidity for accurate alignment of the drift tubes and housing for the power supply and cooling water for the strong focusing magnets mounted within the tubes. After passing through this accelerator, the particles will be injected into the Bevatron. They will make four million orbits within the 120-foot diameter Bevatron reaching an energy of 6.2 billion electron volts before being ejected toward a nuclear research target.

Multiple targets. With the new features, it will be possible to direct beams to several different targets at the same time. With the extracted beam, particles can be directed to remote areas, short-lived particles can be more effectively studied, and experimental freedom and efficiency will be generally increased.

The experimental area was increased during the year with the addition of a 5,000 square foot section to the Bevatron building in the beam area.

In the course of the remodeling extensive maintenance work has been done; for example, new and improved flywheel shafts have been installed in the motor generators to replace the old ones.

As a consequence of the increased beam intensity, it was necessary to install a new concrete shielding system around the above machine. Excavation to provide reinforcement to support the shielding was started in October, 1961, while the machine was still in operation, and erection of the system has been nearly completed. Shielding thickness generally is 10 feet, with a minimum of 7 feet in noncritical areas.

Unexpected HILAC Improvement

The discovery and perfection of unexpected variable energy capabilities in the Heavy Ion Linear Accelerator (HILAC) was accomplished during 1962 at the Lawrence Radiation Laboratory (Berkeley). In a sense the machine is now several HILACs in one, and the development has extensive implications—greatly extending the potential for study of nuclear structure, especially of heavy atoms, through the method of Coulomb excitation.

The unexpected discovery occurred when an experimenter found that his results were in striking disagreement with expectations, and could be explained only if the particles coming from the HILAC had a much lower energy than their normal fixed energy. Careful study showed that the wrong values had been fed into the radiofrequency field toward the end of the 90-foot long cavity of the HILAC post-stripper section. As a result, the particles had received no increments of energy in the "detuned" segment of the cavity, and had arrived at the target with a low energy.

Monochromatic beams. Further experiments conducted under the same conditions consistently repeated the results obtained in the initial experiment. The whole post-stripper cavity or as much of it as desirable can be "detuned." Ions coming from the pre-stripper, at 1 Mev per nucleon, can "coast" through the cavity without receiving further increments of energy; or, increments of energy at any level between

1 Mev and the maximum of 10 Mev per nucleon can be imparted. Moreover, the beams at different energies are nearly monochromatic; that is, all of the particles are of nearly the same energy.

The discovery was astonishing to physicists. Linear accelerators, including HILAC, have been built to produce only fixed energy beams. No provision for frequency variation was attempted in designing the instrument. Some thought had been given to accomplishing variable energies by other expensive adaptations of the instrument—which are now unnecessary.

Important windfall. The implications of the windfall are especially important in *Coulomb* excitation studies. In these studies the experimenter causes charged particles to pass close to nuclei. The Coulomb (electrical) field of the particle causes electrical excitation of the nucleus, making it vibrate and raising it to a higher energy state. The nucleus then emits a gamma ray, and returns to a lower state. The energy of the gamma ray is an indicator of the energy state. Detection of the gamma ray reveals the energy level induced, and this may vary depending upon the particle used and its energy.

The early Coulomb excitation studies were conducted with protons. The heavier ions (oxygen, nitrogen, carbon, argon, etc.) accelerated in the HILAC, having higher Coulomb fields, cause more pronounced excitation in nuclei, enriching the field of study. But with only fixed energies of HILAC beams available—10 Mev per nucleon—the studies were necessarily limited. The beam could be degraded to lower energies with foils, but these measures scatter the particles badly thus limiting the number that can impinge on the target. Another great difficulty is created by the high radiation background which is produced when the HILAC is operated at full capacity.

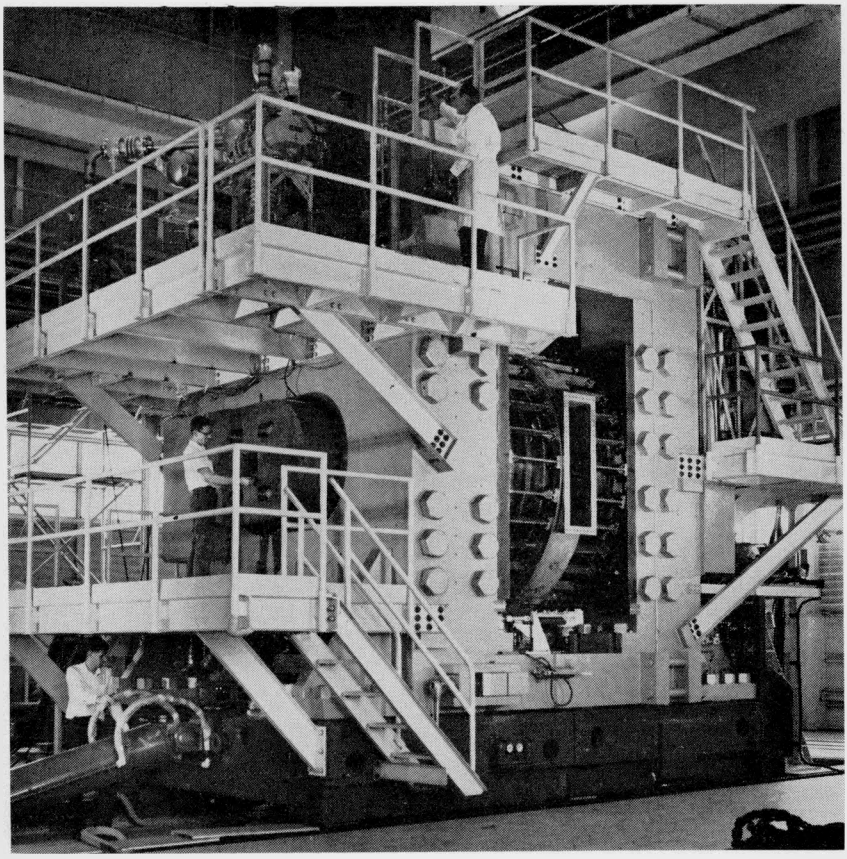
With highly desirable lower, monochromatic energies, ranging from 1 to 10 Mev per nucleon, the capability for eliciting a large amount of new detailed information on the structure and properties of complex nuclei is now achieved.

Alternating Gradient Synchrotron

In operation since July 1960, the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory has been under improvement to increase its usefulness. The AGS is a proton accelerator operating at a nominal energy of 30 Bev and has continued to demonstrate its capabilities as an efficient, effective tool for performing high energy physics research.

The continuing efforts devoted to equipment development and modification have resulted in increased beam intensity and machine

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New Bubble Chamber. The new 80-inch bubble chamber at Brookhaven National Laboratory's Alternating Gradient Synchroton (AGS) accelerator complex is shown when installation was almost completed in October 1962. At the *left* of the carriage is the van for moving the chamber assembly. The entire bubble chamber structure can be elevated and rotated as necesary. At the *left* of the chamber itself, on the first gallery, is the aperture at which photographic and illumination equipment is installed.

reliability, thereby increasing the availability of the facility for experiments. Peak beam intensities of 4.0×10^{11} protons per pulse have been achieved, and intensities of 2 to 3×10^{11} protrons per pulse are routine. On January 15, 1962, the operation of the AGS was increased from two shifts to three shifts per day, 5 days per week.

The 80-inch Hydrogen Bubble Chamber

The 80-inch hydrogen bubble chamber, located in the new North Experimental area of the AGS, was nearly ready for operation at the end of 1962. The stainless steel chamber, 80 x 25 inches and 28 inches

deep, has a useful hydrogen volume of 900 liters and is expanded by an ultra-lightweight 36-inch-diameter piston of honeycomb construction. A 6.5 inch-thick, half-tempered glass plate provides a window for illumination and photography. The entire 450-ton magnet assembly can be transported, rotated, and elevated on the magnet undercarriage as required for experimental or maintenance purposes. The magnet, which contains 30 tons of water-cooled copper windings and 280 tons of magnetic return iron, has a field of approximately 18,000 gauss when powered with 4 megawatts. The building housing the chamber also contains all the facilities needed to operate it, including a 40-ton crane in the 70 x 60 ft. main hall; a compressor room for the operation of hydrogen, nitrogen, and Freon refrigerators and the expansion system; electronic control rooms; and a machine shop. Beams are guided into the chamber through an opening in the AGS magnet ring wall and a connecting beam tunnel.

Cosmotron

The demand for experimental time on the Cosmotron, a 3-Bev proton synchrotron, continues to be high and efforts are continuing to increase the intensity of the machine so as to more easily run several full-scale experiments at one time. The backlog of approved experiments amounts to approximately 1 year of running time.

The Cosmotron operated continuously three shifts per day, 7 days per week, with about two shifts per week scheduled for routine maintenance, except for a 4-month scheduled shutdown (December–April, 1962) for machine improvements and additions to the experimental facilities. This latter work included the installation of new straight sections, additional beam monitoring instruments, and 16 new experimental d.c. power supplies. Considerable work was also done on the Van de Graaff injector, and a new experimental control room was constructed and put into operation. The machine improvements accomplished during the shutdown approximately doubled the beam intensity. Maximum beam intensity is now 8×10^{11} protons per pulse, the highest intensity reported by any proton synchrotron.

CLASSIFICATION AND DECLASSIFICATION

The Commission conducts a continuous review of the local classification and declassification programs in its laboratory and contractor organizations to insure that its policies with respect to release of the maximum amount of information are effectively carried out and to improve and strengthen the declassification programs where possible. During 1962, for instance, a total of 40,000 documents were reviewed

and 38,000 of them were declassified. During the past 16 years, a total of 320,000 documents have been reviewed and 256,000 useful to industry and science have been declassified.

During the past year, the Commission's Division of Classification took steps to make available, on an unclassified basis, information in several major areas of work.

High-temperature Materials

Materials research, especially in the high temperature ranges, has gained a high degree of importance in recent years due to the need for such materials in missiles, nuclear rockets, and other space-oriented uses. A great deal of research and development work on materials of interest in the nuclear reactor program is therefore being performed in laboratories throughout the country. Because of the possible broad applications of this kind of information, the Commission's Division of Classification examined all of the research work being conducted by installations under the AEC's jurisdiction. As a result of this examination, it was possible to develop a unified classification policy which permits a significant amount of this research work to be performed on an unclassified basis. The data thus developed will be made available for public use through the Office of Technical Services. U.S. Department of Commerce, Washington 25, D.C.

Separations Processes

The declassification of the engineering and technology of plutonium-uranium separation processes (*e.g.*, Purex chemical separations process) has made it possible for private industry to lay plans to build and operate a commercial separation plant for recovery of fissionable materials from spent fuel elements from commercial power reactors.

Nuclear Power Plants

In addition, the declassification of the Heat Transfer Reactor Experiments developed under the previously terminated Aircraft Nuclear Propulsion Program [17] has made it possible to design an unclassified small high-power, air-cooled reactor using fully enriched uranium nichrome clad fuel elements for possible use in marine nuclear power plants. No funds for construction of such a plant are available at this time, however.

[17] See pp. 24, 119, "Annual Report to Congress for 1961."

Seismological Data

Information derived from the underground testing of nuclear weapons is of considerable interest to geologists and seismologists who find this information useful in their respective fields. Such information is particularly helpful in improving seismic instruments and instrumentation and also the techniques for interpreting data. It is also helpful in perfecting methods for detecting distant underground explosions. Because of the value of the information to this important segment of scientific endeavor, the Commission made a detailed study to determine what information could be declassified and made available for the public without risk to the national defense and security. As a result, a significant portion of the information obtained from the latest Nevada series of underground shots has been declassified and has been made available to scientists for their use through the National Academy of Sciences and National Science Foundation.

Unclassified Fields of Research

The Commission's "Guide to the Unclassified Fields of Research" has been revised. This guide, first adopted in its present form in 1960, is used by AEC and contractor personnel to define areas of information which have been removed from the category of Restricted Data by the Commission. Two new areas of information have been added to the unclassified fields. The first establishes criteria based on power level and fuel enrichment whereby new work on proposed reactor concepts may be "borne" unclassified. The second places in the unclassified fields the physical and process metallurgy of all elements except plutonium. Heretofore, only the physical and process metallurgy of elements with atomic numbers below 90 were included in the unclassified area.

Rocket Work

In October, the Commission sponsored a joint AEC–NASA fact-finding meeting of experts who studied the implication of classification in the field of nuclear rockets (Rover program). The status, progress, and direction of the project were reviewed with the aim of developing the facts so that the Commission could establish an overall unified classification policy. This set of guiding principles will ensure that technical information on this high priority program is handled in a uniform fashion by all concerned. All data that does not require protection in the interest of the national defense and secu-

rity will be made available for use by industry and the general scientific community through the office of Technical Services of the Department of Commerce.

INFORMATION PROGRAMS

There are three basic objectives in the Commission's over-all public information program. They are, consistent with national security, to: (*a*) fulfill the informational needs of the nation's news media [18]; (*b*) to provide the means for promoting better individual understanding of atomic energy; and (*c*) to provide technical information materials that will be of aid to the scientific and technological community. These programs are conducted by the Commission's Division of Public Information and Division of Technical Information.

FILMS

During 1962, the Commission's 10 domestic motion picture libraries, stocked with more than 200 popular and professional-level films, loaned them for some 104,000 showings viewed by an estimated 3,700,000 persons in high schools, colleges and universities industrial organizations, service clubs, etc. In addition, there was a large audience in educational and commercial television. The film libraries and the geographical areas they supply are listed in Appendix 12.

Approximately 100 films, largely on a professional-level, were on loan from the Commission's liaison offices in London, Tokyo, Brussels, and Buenos Aires, with French and Spanish versions of about 45 films available through the latter 2 offices.

During the year, a depository atomic energy film library was opened at the University of Alaska, and an atomic energy film library to serve the Scandinavian area was opened at the U.S. Information Service in Stockholm. The Commission continued to supply films to the film library of the International Atomic Energy Agency in Vienna.

New Films

The Commission's Division of Public Information added 33 films to its motion picture libraries during the reporting period—a 100 percent increase over calendar year 1961—dealing with such subjects as fuel fabrication, the SL–1 accident, radiation safety, nuclear physics, radiation detection, systems for nuclear auxiliary power for space and land use, atomic research, industrial uses of nuclear energy, etc.

[18] For example, in addition to fulfilling informational requests from news media, the Division of Public Information, during 1962, provided some 12,500 photographs to newspapers, magazines, book publishers, and other public media.

Featured among the additions were the 13 films in the "Challenge" series produced by the National Educational Television and Radio Center (NETRC) under a grant from the Commission's Argonne National Laboratory. The series features in-depth descriptions of basic research by ANL scientists. Also issued during the year were the first five telefilms in a 12-part semitechnical series, "Understanding the Atom," being produced under the technical direction of the Commission's Division of Isotopes Development. They are designed primarily for high school or junior college level science courses and for instructional television.

The Oak Ridge Institute of Nuclear Studies is working with the South Carolina Educational Television Center to produce a TV series centered upon the assembly and classroom presentations of the high school demonstration program which is normally operated as a traveling exhibit.

Motion pictures added were:

Professional-level

PROJECT SEDAN, 8 minutes, color, produced by Lawrence Radiation Laboratory (Livermore). Reports on the July 6, 1962 nuclear cratering detonation at the Nevada Test Site, the first of a series of experiments under the Commission's Plowshare Program to determine the feasibility of nuclear excavations.

CERAMIC FUEL FABRICATION FOR PRTR, 26½ minutes, color, produced by the Hanford Atomic Products Operation, General Electric Co., as contractor for the Commission. Technical explanation of three processes developed by Hanford laboratories for fabrication of UO_2 fuel elements used in Plutonium Recycle Test Reactor (PRTR): cold swaging, hot swaging and vibrational compaction.

SL–1 ACCIDENT: PHASES 1 AND 2, 40 minutes, color, produced by Idaho Operations Office. Résumé of what happened in the Commission's first fatal reactor accident, and how the AEC and its operating contractors reacted—the activities associated with post-accident operations: Phase 1, location, rescue and recovery of three personnel; determination of how much contamination had been released to the environment. Phase 2: determination if reactor was nuclearly safe.

SL–1 ACCIDENT: PHASE 3, 58 minutes, color, produced by Idaho Operations Office; résumé of dismantling of the reactor and the investigation to determine cause of the nuclear excursion.

SRE CORE RECOVERY FOLLOWING FUEL ELEMENT DAMAGE, 29½ minutes, color, produced by Atomics International for the Commission. Summarizes design features of the Sodium Reactor Experiment (SRE), important operations attainments, circum-

stances in 1959 which resulted in severe damage to the core, equipment and procedures to remove radioactive debris and replace reactor components, and modifications to prevent similar future difficulties.

XENON-TETRAFLUORIDE, 5½ minutes, color, produced by Argonne National Laboratory. Current work with the noble gases in chemistry, reporting how ANL scientists have succeeded in making xenon combine chemically with fluorine—the first combination of xenon and one other element, a chemical reaction previously thought to be impossible.

Professional and Popular-level

RADIATION IN PERSPECTIVE, 43 minutes, color, produced by U.S. Department of Agriculture for the Commission. This lecture-demonstration by Francis Brannigan, a safety engineer with the Commission's Division of Operational Safety, relates radiation hazards to other hazards of a modern, industrial society, defines the hazards, shows manner in which hazards are controlled, and explains measures taken in the regulation of uses of radioactive materials.

RADIATION PROTECTION IN NUCLEAR MEDICINE, 45 minutes, color, produced by Bureau of Medicine and Surgery, U.S. Navy. Demonstrates procedures (time, distance and shielding) devised for Naval hospitals to protect against gamma radiation emitted from materials used in radiation therapy from time radioactive materials are received at a hospital through storage, preparation for use, therapeutic administration, nursing care of patients and disposal of radioactive waste.

UNDERSTANDING THE ATOM: ALPHA, BETA, AND GAMMA, 44 minutes, black and white, produced by New York University Television Center; describes the origin and nature of alpha, beta, and gamma radiation.

UNDERSTANDING THE ATOM: RADIATION AND MATTER, 44 minutes, black and white, produced by New York University Television Center. This film, which considers the interaction of radiation with matter, develops the various process by which alpha, beta, and gamma radiation gives up energy to their surroundings.

UNDERSTANDING THE ATOM: RADIATION DETECTION BY IONIZATION, 30 minutes, black and white, produced by the Educational Broadcasting Corp. Basic principles of ionization detectors are described. Brief descriptions of ionization chambers, proportional counters and Geiger counters are included, and examples of instruments operating in these regions are shown.

UNDERSTANDING THE ATOM: RADIATION DETECTION BY SCINTILLATION, 30 minutes, black and white, produced by the Educational Broadcasting Corp. Film features: descrip-

tion of scintillation process, solid and liquid scintillators, operation of photomultiplier tube, concept of pulse height analyzer.

UNDERSTANDING THE ATOM: PROPERTIES OF RADIATION, 30 minutes, black and white, produced by the Educational Broadcasting Corp. Features: radiation decay, concept of half-life, statistical considerations, energy spectrum from alpha and beta emitters, use of absorption curves to study energy distribution of beta radiation, self-absorption, specific activity, and backscattering.

Popular-level

ATOMS FOR SPACE, 28½ minutes, color, produced by Atomics International and the Martin Co. for the Commission. Describes development and use of compact nuclear power sources for space using either decay of radioactive isotopes or small nuclear fission reactors to generate heat, under the Commission's Systems for Nuclear Auxiliary Power (SNAP) programs. Features the first use of atomic power in the nation's space effort, and also covers briefly uses of SNAP devices on land and sea.

BASIC PRINCIPLES OF POWER REACTORS, 8½ minutes, color, produced for the Commission by the USAF's Lookout Mountain Air Force Station. Via animation, describes nuclear power reactors and how they produce steam for the generation of electricity: fission, controlled chain reaction and the function of basic reactor components. Various reactor concepts and types of fuel elements are explained.

CHALLENGE: INVISIBLE BULLETS, 29 minutes, black and white, produced by NETRC. The meaning of radiation, its natural sources, the various forms it takes, the difference between alpha and beta particles and between gamma and X-rays, how radiation is used in research.

CHALLENGE: WORKING WITH RADIATION, 29 minutes, black and white, produced by NETRC. Precautions used in working with radiation, and research to learn more about handling radiation. Illustrated are "hot caves" with mechanical slave manipulators or electric manipulators, and giant "caves" using heavy duty manipulators. Demonstration outlines method of disposing of radioactive wastes.

CHALLENGE: SEARCHING FOR THE ULTIMATE, 29 minutes, black and white, produced by NETRC. Explanation of how particle accelerators work to produce intense beams of radiation to enable study of the structure of the atom, the nucleus, and the basic components of the nucleus. Includes a tour of the Zero Gradient Sychrotron at Argonne National Laboratory. Explanation of the subnuclear particles in which the high energy physicist is interested, the concept of matter and anti-matter.

CHALLENGE: ATOMIC FURNACES, 29 minutes, black and white, produced by NETRC. Operations, principles, and scientific uses of nuclear reactors are described, with major film time devoted to the types of research that reactors make possible. Described are the gamma ray spectrometer, the neutron chopper, and the "Janus" reactor at Argonne National Laboratory for experiments in biology.

CHALLENGE: RADIATION AND THE POPULATION, 29 minutes, black and white, produced by NETRC. An explanation of the genetics research program to learn how radiation damages cells and what the long term effects of such damage might be; how radiation causes mutations and how these mutations are passed to succeeding generations. Experiments with mice and fruit flies are discussed.

CHALLENGE: TIME—THE SUREST POISON, 29 minutes, black and white, produced by NETRC. Explores the natural process of aging and the use of radiation to study aging. Illustrated with research with animals and in the low level gamma irradiation room.

CHALLENGE: THE IMMUNE RESPONSE, 29 minutes, black and white, produced by NETRC. Concerned with the mechanism by which the body builds antibodies against disease and other foreign substances and with the effects of radiation on this immunizing response. Demonstration of research with X-irradiation of rabbits.

CHALLENGE: BUILDING BLOCKS OF LIFE, 29 minutes, black and white, produced by NETRC. Free radicals—unique fragments of molecules caused by radiation in living systems—either kill or seriously damage living cells. The how and why of both the particles and the damage they cause is covered in the film.

CHALLENGE: THE LIVING SOLID, 29 minutes, black and white, produced by NETRC. Bone is shown to be an active, living substance. The importance of bone to the entire body as a supplier of calcium is emphasized, and the systems by which this calcium gets from bone to blood and vice versa is illustrated. Effects of radiation are illustrated in photos of bone cross-sections.

CHALLENGE: TRACING AIRBORNE RADIOACTIVITY, 29 minutes, black and white, produced by NETRC. A discussion of how the air cleanses itself of poisonous and radioactive substances; examination of atmospheric fallout and methods used to determine and study such fallout; relation of fallout studies to man and his environment.

CHALLENGE: TRACING LIVING CELLS, 29 minutes, black and white, produced by NETRC. The use of radioactive isotopes in the study of cell division and in medical therapy; use of radioactive tracers in blood and cancer research.

CHALLENGE: THE ART OF SEPARATION, 29 minutes, black and white, produced by NETRC. With radiation, the chemist is able

to work with much greater speed and ease in the field of chromatography—the separation of chemical compounds into basic substances. Basic principles are explained, with a demonstration of an actual separation of a chemical compound.

CHALLENGE: FOUNDATIONS FOR THE FUTURE, 29 minutes, black and white, produced by NETRC. Discussion of what the future will bring in the various areas of basic nuclear research—the effects of radiation, the peaceful uses of radiation and the dangers of radiation.

OPPORTUNITY UNLIMITED: FRIENDLY ATOMS IN INDUSTRY, 28 minutes, color, produced by the Army Pictorial Center for the Commission; narrated by John Daly, a summary of the industrial application of radioisotopes in nuclear gaging, radiography, and tracing.

RADIATION IN BIOLOGY: AN INTRODUCTION, 13½ minutes, color, produced by Coronet Instructional Films at Argonne National Laboratory. Nature and sources of radiation, radioisotopes, comparison of plants from irradiated and nonirradiated seeds, bone marrow sample from irradiated animal, effects of radiation on blood cells, intestines, and chromosomes. Use of radioisotopes for tracer studies, autoradiographs, etc.

RADIATION SAFETY IN NUCLEAR ENERGY EXPLORATIONS, 24 minutes, color, produced by Division of Radiological Health, U.S. Public Health Service, in cooperation with AEC. Describes radiation-safety activities of USPHS in environmental surveillance of radiation and protection of public health during AEC nuclear energy experiments on peaceful uses of nuclear explosives, aerospace program, and seismic research in detection of underground nuclear detonations. Collection and analysis of air, water, milk, food samples; ground and aerial monitoring; film badges and fallout tray programs; veterinary program, etc.

ROUNDUP, 18 minutes, color, produced by the Agriculture Research Service of the U.S. Department of Agriculture. Use of radiation to eradicate the screwworm fly in the southeastern United States. Shows cycle of the insect pest, typical animal infestation, use of radioactive cobalt to sterilize single-mating male flies, release of flies from aircraft over infested areas.

STORY OF CAMP CENTURY: CITY UNDER THE ICE, 32 minutes, color, produced by the Army Pictorial Center. Covers construction by Army Engineers of Camp Century, a nuclear-powered U.S. Army arctic research laboratory buried below the Greenland icecap. Contains section devoted to the nuclear power plant for electricity and space heating, including sub-critical tests, loading of reactor core, etc.

TECHNICAL INFORMATION ACTIVITIES

The wealth of varied information being derived from work done in the nation's atomic energy field is made available to the scientific and technical communities through a number of Commission-sponsored methods which are administered by the Division of Technical Information.

Technical Publications

Nuclear Science Abstracts (NSA)

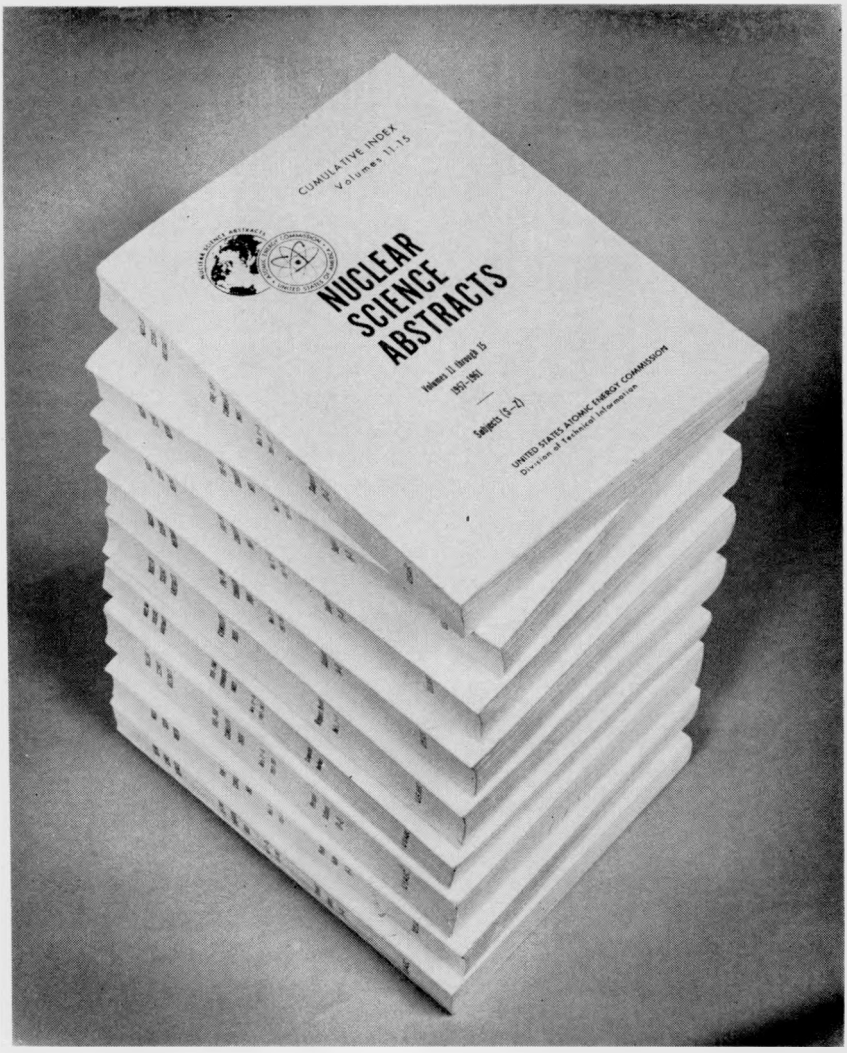
The only abstract journal in the world devoted solely to nuclear science and technology, the Commission's Nuclear Science Abstracts provide scientists and engineers in the national nuclear energy program and the international scientific community with an awareness of the current nuclear literature as well as the means for retrospective searching.

In May 1962, a new 5-year cumulative index to the NSA was completed. It comprises 9 volumes of personal author, corporate author, subject, number indexes and public availability citations, covering approximately 115,000 scientific and technical reports and articles which were included in NSA issues from 1957 to 1961 (Volumes 11–15). This new multivolume index is the third such cumulation which has been issued. The two prior multivolume indexes covered NSA Volumes 1–4 and 5–10.

Research and Development Abstracts (RDA)

This publication was begun early in 1962 on an exprimental basis to announce, abstract, and index a considerable body of unclassified AEC-generated material and translations, outside the subject scope of Nuclear Science Abstracts, which were not previously under bibliographic control. The abstracting, format, and indexing style is similar to that of NSA as are the reports announced and the public availability.

In addition to announcing unclassified AEC-generated material outside the scope of NSA, the Research and Development Abstracts will be used as a vehicle for experimenting with various approaches to cataloging, abstracting, and indexing. RDA will be published approximately four times a year and will be distributed to all recipients of NSA. It will also be sold through the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for 50 cents per issue. Since the journal will be published irregularly, it will not be sold on a subscription basis.



Five-Year Index. During May 1962, the AEC published a new cumulative index for volumes 11–15 (1957–1961) of its Nuclear Science Abstracts (NSA), the only such journal in the world devoted solely to nuclear science and technology. The nine-volume index is divided into four parts: subject index, personal author index, corporate author index, and report number index. Nearly 115,000 scientific and technical reports and articles in the field of atomic energy are represented in the five-year index.

Engineering Materials

The Commission continued its program of making available (United States and foreign), upon request from the public, industrial firms, universities, and government agencies, any unclassified engineering materials developed by the AEC and its contractors. Several thousand additional new engineering drawings were announced during this year which increased the total collection available to 38,000 items. During 1962, approximately 67,000 full-size blue-line print copies of engineering materials (drawings, specifications, and photographs) were sold by the Cooper-Trent Blueprint and Microfilm Corp., the reproduction and sales contractor for this material for the Commission. The Commission received 750 requests for copies of engineering materials from the United States and foreign industrial firms. Requests were also received from more than 100 universities and colleges for engineering drawings of equipment for training purposes in radiochemistry and industrial radioisotope devices.

Bibliographies and Literature Searches

The Commission prepared and published four formal bibliographies on the following subjects during calendar 1962: Nuclear Explosion Effects on Structures; Radiation Shields and Shielding; Plutonium; and Reactor Graphite. These are annotated bibliographies and contain extensive subject and author indexes.

Two important annotated bibliographies covering worldwide literature in the field of radiobiology were in process. One covers the period 1895–1957 and will contain approximately 10,500 references. The other, which will be issued early in 1963, covers the period 1958–60 and will contain approximately 12,000 references. It is noteworthy that the bibliography covering the three year period contains more references than that for the previous 65 years. A "bibliography of bibliographies," [19] containing 2,470 references to bibliographies and literature surveys on various aspects of atomic energy, was prepared and published by the Division of Technical Information in August.

At the request of Government agencies, Government contractors, and the public, 327 literature searches on various specific subjects were performed.

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[19] "Bibliographies of Interest to the Atomic Energy Program," TID–3043 (Rev. 2), is a complete revision of all previous editions and is available from the Office of Technical Services, Department of Commerce, Washington 25, D.C., price $4.

Technical Books and Monographs

The Commission has had an active program of sponsoring the writing and publication of books, monographs, and reference works in the field of nuclear science and technology since 1947.[20]

In 1962, the following books were published: Reactor Handbook (2d Ed.), Volume 3, Part A, Physics; Reactor Handbook (2d Ed.), Volume 3, Part B, Shielding; Nuclear Propulsion for Merchant Ships; The Effects of Nuclear Weapons—1962; Nuclear Reactor Fuel Elements—Metallurgy and Fabrication; Neutron Absorber Materials for Reactor Control; Nuclear Graphite; and Radiation Effects on Organic Materials.

By the end of 1962, eight books and three monographs were ready for publication: Reactor Handbook (2d Ed.), Volume 4, Engineering; Atomic Energy Deskbook; Nuclear Reactor Engineering;[21] Handbook on Medical Aspects of Radiation Accidents; Nuclear Reactor Control Engineering; Irradiation and the Nervous System; A Manual of Experiments in Reactor Physics; Uranium Metallurgy, Volume 2; Fabrication of Control Rods for Nuclear Reactors (monograph); Advanced Techniques in Powder Metallurgy (monograph); and Materials for Control Drive Mechanisms (monograph).

Additionally, at the end of 1962, two books and six monographs had been completed but were not yet published: Thermal Stress Techniques in the Nuclear Industry; Treatment and Disposal of Low-Level Radioactive Wastes; Pulmonary Deposition and Retention of Aerosols; Particle Size Analysis in Industrial Hygiene; Materials for Control Drive Mechanisms; Radiation Effects on the Toughness of Ferritic Steels; Reactor Noise; and System Analysis of Nuclear Reactor Dynamics. The first two are books and the remainder monographs. The Commission's monograph program was continued with the cooperation of four technical societies: American Institute of Biological Sciences, American Nuclear Society, American Society for Metals, and the American Industrial Hygiene Association.

The objective of this program is to sponsor the writing and publication of concise, authoritative treatises on selected subjects in nuclear science and technology, realizing a shorter writing and publication schedule and lower retail price than is generally possible with full size technical books.

Contracts were awarded for a comprehensive treatise on reactor safety, and four books, entitled: Mathematical Theory and Applications of Radiation Dosimetry; Neuclear Physics; Neutron Thermalization; and a "Shielding Handbook".

[20] A complete listing of books and monographs published or being prepared under this program may be found in the booklet, "Technical Books and Monographs". Available without charge from the Division of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn.

[21] Revised edition of "Principles of Nuclear Reactor Engineering."

Technical Progress Reviews

Four quarterly Technical Progress Reviews—Nuclear Safety, Power Reactor Technology, Reactor Materials (formerly Reactor Core Materials), Reactor Fuel Processing—are published by the Commission. Each of the four reviews covers the developments in a particular area of the nuclear energy field and is prepared for both technical and management people. A subject index is provided for each of the reviews.[22]

Contracts were awarded during 1962 for the preparation of the following new technical reviews:

"*Isotope and Radiation Technology*". This review will cover all aspects of radioisotope technology under the Commission's Isotope Development Program. Included will be isotope development and production, activation, and radiometric analysis, tracer techniques, measurement and control systems, isotopic power, nondestructive testing and applied radiation processing. The first issue will be published in April 1963.

"*Annual Review of Reactor Technology*". This review, to be published in book form, will identify and treat those areas of technology related to civilian power reactors in which major advances toward competitive nuclear power have been achieved during the review period. The first issue will be published January 1964.

Publication Exchanges

The Commission seeks to make its coverage of the literature of nuclear science world-wide in scope. An important means of achieving this end is through publication exchanges whereby *Nuclear Science Abstracts* and other Commission-sponsored publications are offered in return for the scientific publications of foreign and domestic research establishments. Organizations in 48 foreign countries send their publications in nuclear science to the Commission under this exchange.

The publications are abstracted and indexed in NSA if they are within the subject scope of that journal. Research and development reports that are received on exchange are made available in the United States through the Commission's Division of Technical Information and depository libraries; books and journals are deposited with the Library of the Oak Ridge Institute of Nuclear Studies and are available on interlibrary loan. The Commission has a total of 630 publication exchanges.

[22] See p. 276, "Annual Report to Congress for 1961" for scope of each review.

Translations

Approximately 800 Commission-sponsored translations were announced in *NSA* during the year, distributed to official requesters, and made publicly available through the Office of Technical Services of the Department of Commerce, and the Special Libraries Association Translation Center at the John Crerar Library in Chicago. Among the translated monographs were the following titles: Boron—Its Compounds and Alloys; Methods and Applications of Mass Spectroscopy; Corrosion of Reactor Materials; Radiation Protection Handbook; Transition Metal Hydrides; Sanitation Rules in Handling Radioactive Substances and Sources of Ionizing Radiation; Evaluation of the Contamination of the Biosphere by Products of Nuclear Tests; Magnetic Flow Detection, Nondestructive Testing, Analysis and Measurements; and Heat Transfer Problems. All were translated from Russian, with the exception of "Methods and Applications of Mass Spectroscopy" which was translated from German.

The Commission sponsored the cover-to-cover translations of the following journals: *Radiokhimiya*, Vol. 2, 1960, and Vol. 3, 1961; *Zhurnal Neorganicheskoi Khimii*, Vol. 2, 1957, and Vol. 3, 1958; *Uspekhi Fizicheskikh Nauk*, Vols. 61, 62, and 63, 1957, and Vols. 64 and 65, 1958; *Nukleonika*, Vol. 2, 1957, Vol. 3, 1958, Vol. 4, 1959, Vol. 5, 1960, and Vol. 6, 1961; and also *Roczniki Chemii*, 1959 and 1960. The first three were translated from Russian and the last two from Polish.

Supplement No. 1 to the indexed title-listing of all Commission-held translations was in preparation. Approximately 3,000 translations are listed and indexed by source and author. A brochure, "Selected Technical Translations Sponsored by the USAEC", was published in 1962. This brochure describes 84 major works that have been translated and distributed by the Commission.

The Commission's translations are announced in the publication, "Technical Translations", issued by the Office of Technical Services of the U.S. Department of Commerce, and in the European Atomic Energy Community (Euratom) translation announcement bulletin, "Transatom Bulletin".

Distribution of Reports

A total of 1,350 copies of classified reports was sold during 1962 to Access Permit Holders under the Commission's Civilian Applications Program, and 156,000 copies of unclassified reports were provided to the Department of Commerce, Office of Technical Services (OTS), for sale to the public. During the year, 6,750 new unclassified report titles were made available for sale through OTS, and were added to

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the collection of the Depository Libraries throughout the United States and abroad, bringing the Depository collection to a new total of approximately 52,000 in domestic libraries and 45,000 in foreign libraries.

Depository Libraries

During 1962, four additional Commission Depository Libraries—two domestic and two foreign—were established. In the United States, a new library was located at the University of Colorado. The University of Colorado was also designated a Regional Depository Library that will house and service collections of U.S. Government Reports in addition to those of the Atomic Energy Commission. Twelve such regional depositories have been established under the program sponsored by the National Science Foundation and administered jointly by the Office of Technical Services, Department of Commerce and the associated AEC Depository Libraries. The Oak Ridge Institute of Nuclear Studies was also designated an AEC Depository Library.

Abroad, AEC Depository Libraries were established in Malaya and Bolivia.

There are now 88 AEC Depository Libraries in the United States and 87 located outside the United States, assigned to 63 countries and 6 international organizations concerned with atomic energy. (See Appendix 13 for locations.)

Technical Information Workshops

The Commission sponsored or cosponsored several workshops for librarians during the year to stimulate the utilization of nuclear energy information. The Inter-American Nuclear Energy Commission, the Pan American Union, and the U.S. Atomic Energy Commission have cosponsored four workshops in Latin America (two in 1961) as follows:

Rio de Janeiro, Brazil	April 22–May 10, 1961
Lima, Peru	October 16–21, 1961
Mexico City, Mexico	April 9–16, 1962
Santiago, Chile	November 5–10, 1962

Approximately 186 librarians and information officers from 17 Latin American countries participated in these workshops. The importance of the literature and its part in the uses of nuclear energy for peaceful purposes was emphasized at these sessions. Emphasis was also placed on the use of the report collections that have been made available by the Atomic Energy Commission to 12 countries in Latin America.

On September 11–13, 1962, the Commission held a meeting of AEC contractor and depository librarians at its Division of Technical Information Extension in Oak Ridge, Tenn. This meeting was attended by approximately 150 people who discussed various topics on library and documentation procedures, machine applications, and indexing approaches.

Exhibits

The Commission's exhibits program includes a wide variety of manned and unmanned units, ranging from specially prepared demonstrations for professional-level groups to exhibits for high school and county fair audiences. During 1962, the Commission took an active part in promotion of "science fairs" for high school students.

Professional Exhibits

To meet the need for presenting atomic energy program information at the professional level, the Commission's Division of Technical Information began developing special exhibits for scientific and technical meetings. These included:

"*Atomic Energy Construction*," an exhibit which called attention to unique features of construction in nuclear reactors, atomic laboratories, high energy accelerators, and other plants and equipment peculiar to the nuclear industry. The exhibit was shown at the annual convention of Associated General Contractors in Los Angeles.

"*AEC RESEARCH—Biological, Medical, and Environmental*," an exhibit which presented research programs of the Commission's Division of Biology and Medicine, was displayed at meetings of the Federation of American Societies for Experimental Biology in Atlantic City, N.J., the American Institute of Biological Sciences in Corvallis, Oreg., and the American Association for the Advancement of Science in Philadelphia, Pa.

"*AEC RESEARCH—A Basis for Health Physics*," similar to the biological and medical exhibit described above, except that it emphasized new devices for detecting and measuring radiation throughout the explored cosmos, was shown at the annual meeting of the Health Physics Society in Chicago.

"*FALLOUT IN PERSPECTIVE*," developed for the meeting of the American Medical Association in Chicago, was later sent to the American Chemical Society meeting in Atlantic City, the 1962 Youth Conference on the Atom in Chicago, and the National Conference on Air Pollution in Washington, D.C. The rest of the time it was in the AEC exhibit at the Chicago Museum of Science and Industry. While



Professional Meeting Exhibit. Typical of the specialized AEC exhibits for use at large national professional and scientific meetings is this 20-foot display pictured during its inaugural showing at the annual meeting of the Federation of American Societies for Experimental Biology, at Atlantic City, N.J., in March. AEC attendants guide visitors to literature pertaining to their fields of work and provide knowledgeable, on-the-spot answers to numerous visitor questions about program trends, project assistance, and the like. An interesting feature was the white rat (shown in *lower right*) as he ran a plexiglas maze during a demonstration experiment on effects of massive accumulated doses of gamma radiation upon brain function.

acknowledging potential and actual dangers of fallout radiation, this exhibit compares levels of radiation from fallout with levels from other sources—such as medical X-ray equipment, luminous-dial wristwatches, and natural sources—which man encounters and accepts in daily life. The exhibit also explains the effects of winds, radioactive decay, half-life, and ecological cycles on the distribution and intensity of radioactive fallout.

"*REGULATING THE ATOM—A JOINT AEC-STATE EFFORT*" summarizes progress being made by the States toward their regulating, handling and use of radioactive materials. The regulatory process is still a Federal function in most States. The exhibit was displayed at the annual meeting of the American Public Health Association in Miami Beach, Fla.

"*NUCLEAR AGE METALLURGY*," presents highlights of metallurgical research sponsored by the Commission, including a display from the Oak Ridge National Laboratory on techniques developed for manufacturing certain difficult-to-fabricate reactor components. The exhibit was shown in New York City at the World Metal Show of the American Society for Metals and in Washington, D.C.,

at the Atom Fair of the American Nuclear Society and the Atomic Industrial Forum.

"*POWER FROM ISOTOPES*," displays a new SNAP (Systems for Nuclear Auxiliary Power) isotopic power source and includes a demonstration of the use of its electricity to operate telemetering equipment suitable for transmitting physiological data from an astronaut back to earth. It was shown at the Atom Fair in Washington, D.C., and at an exposition for the public in Whittier, Calif. The telemetering equipment was furnished and operated by the U.S. Naval Medical Research Institute, Bethesda, Md.

The exhibits mentioned above frequently reuse the same background structure with different illustrations, diagrams, models, etc., for different subjects. Whenever practical, each exhibit is shown on several occasions.

Traveling Exhibits

The "*This Atomic World*" high school demonstration exhibit was increased late in 1961 from 6 to 11 units, and all 11 units were on tour throughout the school months of 1962. Additionally, one of the units assigned to the "*Your Stake in the Atom*" combination exhibit remained with that exhibit throughout the summer during engagements at large fairs. During the summer, 4 of these demonstration units were combined in 4 portable pavilions with 4 of the 10 (normally unmanned) "Atoms in Action" package units to form special "Summer Fair" exhibits which filled engagements from early June through mid-September when the trained demonstrators returned to their regular exhibit work before student audiences. The 10 package exhibits filled 162 requests for special showings during the year.

The two large, manned "*You and the Atom*" exhibits and the remaining two "*Atoms at Work*" mobile exhibits were retired. Design work was accomplished for a new exhibit for large fairs and for exhibits to be displayed for a few weeks at a time in museums throughout the country.

During 1962, AEC traveling exhibits filled a total of 1,956 engagements in 47 States and were viewed by an estimated 5,573,000 persons.

Stationary Exhibits

With attendance increasing to 119,000, the American Museum of Atomic Energy at Oak Ridge, Tenn., continued to enlarge its services to the Southeast and to the Nation. The visitors came from 50

States and 90 foreign countries. Foreign visitors include groups such as 71 American Field Service students representing 19 countries, 46 exchange students from 6 countries, and 39 World International Bank representatives from 15 countries. More than 15,000 of the visitors were students in organized tours from 413 high schools. Most visitors to the museum are conducted in groups by trained guides who, in the course of a tour, seat their vistors for three different lecture-demonstrations. Both the Museum and the Traveling Exhibits Program are operated for the Commission by the Oak Ridge Institute of Nuclear Studies.

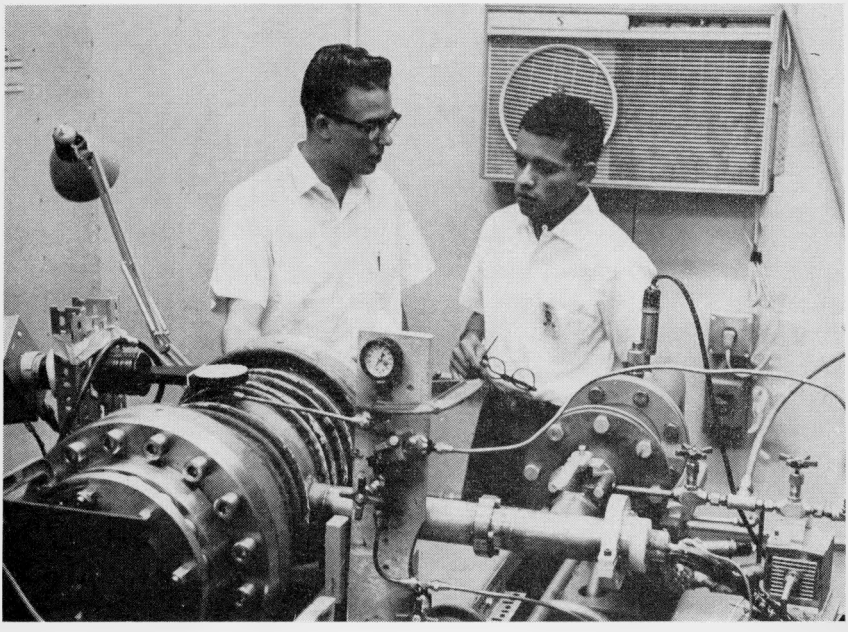
Since the 1955 and 1958 Geneva Conferences on the Peaceful Uses of Atomic Energy, the Commission has exhibited displays from these conferences in the Museum of Science and Industry in Chicago. During the year, the Commission, through Argonne National Laboratory, renovated and updated the exhibit. Plans are for the Laboratory to continue the improvement and, from time to time, add displays on new developments. The Chicago museum has more than 2.5 million visitors a year.

Science Fairs

In recognition of the growing contribution of science fair exhibits to the career interest of participating high school students and to public understanding of science, the Commission instituted a special AEC awards to National Science Fair-International entrants preparing outstanding nuclear-related exhibits. At the 1962 national fair, held at Seattle in March, judges winnowed the 390 different exhibits, identified 80 as nuclear-related, and from these chose 10 award winners and 10 alternates. Winners and alternates received certificates of achievement.

In August, the 10 winners—8 boys and 2 girls—and their science teachers were guests for a week at the Commission's Argonne National Laboratory near Chicago, where they talked with scientists about their work, watched the progress of a number of unclassified research and development projects, toured Argonne's varied research facilities, and received a closeup view of the way atomic scientists work and live.

The Commission also participated in the 1961 and 1962 National Youth Conferences on the Atom, held in Chicago, each attended by 600 specially selected science students and their teachers. AEC Headquarters and facilities supply exhibits, publications, and speakers for the conferences. Chairman Glenn T. Seaborg was the principal guest lecturer at the 1961 conference.



Young Scientist. In August, the Commission's Argonne National Laboratory played host for a week to the ten AEC Special Award winners in the 1962 National Science Fair-International and their science teachers. Both students and teachers were afforded extensive familiarization with the many different programs of unclassified research conducted by Argonne, after which the student winners discussed their individual fields of interest with staff scientists engaged in related research. Here, an Argonne physicist, explains use of this research spark chamber in cosmic ray studies to John Taboada, (*right*), of San Antonio, Texas, whose winning NSF–I exhibit dealt with studies similiar to those conducted at Argonne with a spark chamber.

Educational Literature

During 1962, the Commission and its major contract operators of AEC facilities furnished approximately 92,000 packets of informational literature and references in response to requests for a variety of information on atomic energy. As in past years, the requests came chiefly from secondary school students. Requests were also received from college and elementary school students, teachers, librarians, and guidance counselors; from teachers' institutes, adult study groups, special conferences and seminars, and from the general public.

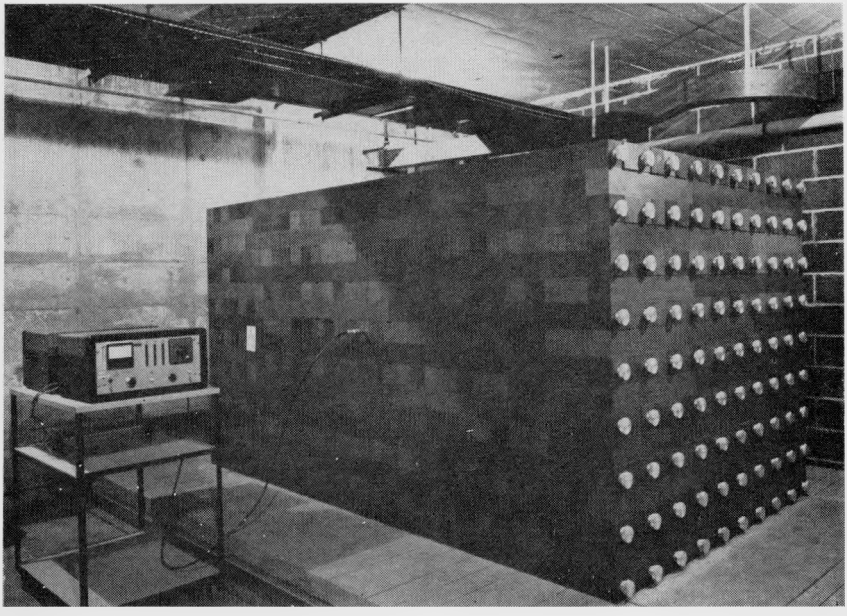
During the last half of 1962, the Commission published the first booklets of the series, "Understanding the Atom," which are being written to simplify and improve the answering of these inquiries. These include "Careers in Atomic Energy," "Power from Isotopes," and "Atoms in Agriculture," and are available from the Division of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn.

EDUCATION AND TRAINING

The Commission established a Division of Nuclear Education and Training in July 1962, for the purpose of consolidating and strengthening its programs of assistance to nonprofit educational institutions. Nuclear education and training programs which have been integrated to form the new division include those in the engineering and physical sciences, previously administered by the Coordinator of Nuclear Education and Training, and the Division of Isotopes Development; and those in the life sciences, previously administered by the Division of Biology and Medicine. In addition to administering these programs, the new division is responsible for developing and maintaining Commission-wide education and training policies and for reviewing and coordinating all Commission programs on education and training.

ASSISTANCE ACTIVITIES

The Commission's educational assistance activities are designed to aid educational institutions in accomplishing the following four major objectives: (*a*) to assure a continuing supply of capable nuclear scientists and engineers for the atomic community; (*b*) to diffuse nu-



Typical Aid. Typical of the nuclear materials services provided by the AEC to colleges and universities for nuclear technology instruction is the above graphite-natural uranium subcritical assembly at the University of Minnesota. Since the inception of this program in 1956 the Commission has made available $13.4 million worth of equipment to 252 schools.

clear technology throughout all pertinent curricula; and (*c*) to assist in orienting the public on nuclear energy.

Specific activities administered by the new Division of Nuclear Education and Training include equipment grants, nuclear materials services, faculty institutes, fellowships, operation of courses, faculty participation at AEC sites, and university-national laboratory cooperation.

Equipment Grants

Colleges and universities are provided funds for the acquisition of specialized equipment to be used in nuclear education programs at the graduate and undergraduate levels in the engineering, life, and physical sciences. These funds are used for the purchase of such laboratory apparatus and equipment as radiation detection, monitoring, and counting instruments; subcritical assemblies; neutron howitzers; small particle accelerators; and computers for reactor simulation and nuclear problem solving.

The scope of the Commission's equipment grant program during 1962 and since the grant program was started in 1956 is summarized below.

	No. of Institutions Receiving Grants		*Amount Granted (In millions)*	
	CY 1962	*To date*	*CY 1962*	*To date*
Equipment grants in engineering and physical sciences	143	386	1. 6	18. 2
Equipment grants in life sciences	84	329	0. 7	5. 4
Total	[a] 213	[b] 569	2. 3	23. 6

[a] During CY 1962, 13 institutions receiving grants in both the physical and life sciences.
[b] 146 institutions have received grants in both the physical and life sciences.

NUCLEAR MATERIALS SERVICES

Loan of Nuclear Materials

In a program closely related to the equipment grants program, the AEC lends to colleges and universities, without charge, such source, special nuclear, byproduct, and other materials as are needed for nuclear technology instruction. Typical materials covered under this program are natural uranium and graphite for subcritical assemblies, uranium enriched in uranium 235 for fission counters and fission plates, plutonium contained in neutron and alpha sources, and heavy water.

During 1962 the Commission approved loans to 32 schools of materials valued at $0.94 million. Since inception of the program in 1956, 252 schools have received materials valued at $13.4 million.

Research Reactor Assistance

Research and development in the nuclear aspects of engineering and the life and physical sciences are encouraged by the Commission through direct assistance to university research reactor projects. This assistance includes funds for fabrication of reactor fuel elements, for startup neutron sources, and the loan of enriched uranium contained in such fuel elements without charge for use, burnup, normal loss, and reprocessing after use. Heavy water for use as a reactor moderator is also loaned without charge. Under this program in 1962, the Commission agreed to: loan additional fuel materials for the reactors at the State University of New York at Buffalo (formerly the University of Buffalo) and Georgia Institute of Technology, and loan additional heavy water for the Massachusetts Institute of Technology reactor. The value of materials approved for loan was $55,800. Since inception of the program in 1954, reactor projects have been assisted in this manner at 10 educational institutions, the total value of materials approved for loan being $1.8 million and the total funds authorized for fuel fabrication being $622,000. The program is carried out in cooperation with the National Science Foundation which provides grants towards construction of university research reactor facilities.

Faculty Institutes

Engineering and Physical Sciences Institutes

The past year represented the seventh consecutive year that summer institutes have been conducted under the joint sponsorship of the Commission and the American Society for Engineering Education (ASEE) to provide opportunities for advanced training in nuclear science and engineering. Ninety-eight faculty members attended six institutes held at five campuses: Iowa State University, University of Illinois, University of Florida, University of Washington, and North Carolina State College. Since the inception of this training program, a total of 807 members of faculty from 170 institutions have been registered at 41 AEC–ASEE summer institutes.

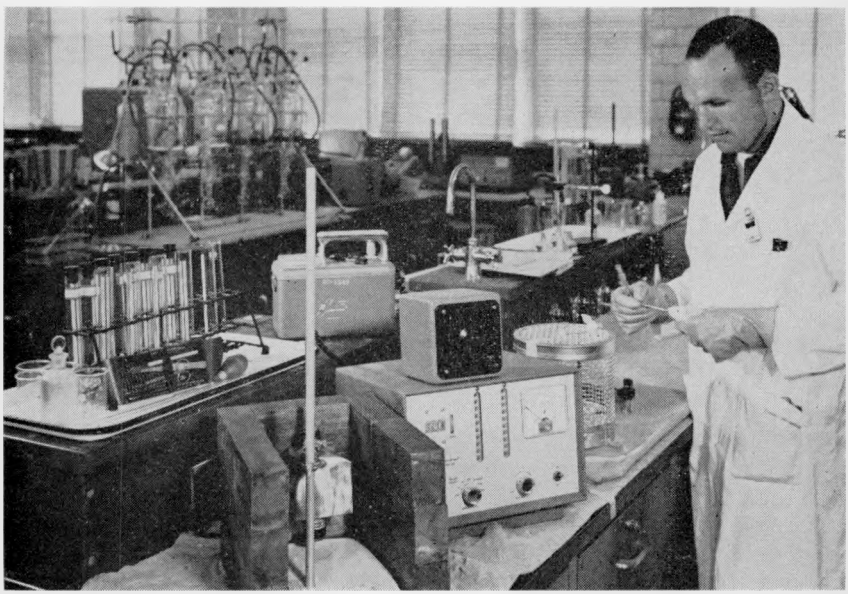
During 1962, eight 6-to-8 week summer institutes were co-supported by the Commission and the National Science Foundation for small college science faculty in radioisotope techniques and radiation phenomena. One hundred eighty-one faculty members participated in these institutes.

Radiobiology Training Institutes

During the summer of 1962, the Commission and the National Science Foundation cosupported twenty-five 6-to-8 week courses in radiation biology. Eighteen were for high school teachers, five for college teachers, and two for high school and college faculties combined. These courses were held at 23 universities and the Oak Ridge Institute of Nuclear Studies. In the fall of 1962, 2 in-service sessions, of 1 to 2 classes per week, were conducted at 2 universities (Shorter College, in Rome, Ga., and at Texas Woman's University at Denton, Tex. for 24 high school teachers. Full academic year courses in radiation biology were held for 20 college teachers at Cornell University and the University of Minnesota. To date, 1,524 high school teachers and 253 college teachers have received training in 89 institute sessions conducted over the past 6 years.

Methods in Radiation Biology

Argonne National Laboratory enrolled 13 biologists, primarily university staff members, in a course in Methods in Radiation Biology held June 25 through July 20, 1962. The course, offered by the Labo-



Educational Support. Colleges and universities are provided funds by the AEC for acquisition of specialized equipment to be used in nuclear education programs at the graduate and undergraduate levels in the engineering, life, and physical sciences. Photo shows a Cornell University student using such equipment in a study of phosphorus 32 distribution in a rat after its ingestion.

ratory's Biological and Medical Research Division, consisted of lectures, demonstrations, and laboratory work.

Fellowships [23]

Engineering and Physical Sciences

The nuclear science and engineering fellowship program had its start in 1957–58 with 96 first-year appointments. Including the 1962–63 appointments of 179, a total of 866 fellows have received appointments for study at the first, intermediate, or terminal-year level. Fifty-nine universities in the United States are participating in this nuclear science fellowship program.

Life Sciences

Thirty-nine health physics fellows have been selected for the current 1962-63 academic year. Twenty-three of last year's fellows are continuing graduate study. Approximately 639 fellows have received this specialized training since 1950 at various universities and Commission installations. Institutions presently participating in this program are: Vanderbilt, Puerto Rico, Rochester, Harvard, Michigan, Kansas, Washington (Seattle), California (Berkeley) universities, together with Oak Ridge, Brookhaven, and Argonne National Laboratories, General Electric Co. (Hanford, Wash.), National Reactor Testing Station (Idaho), and E. O. Lawrence Radiation Laboratory, University of California (Berkeley and Livermore, Calif.).

The advanced health physics fellowship program began in the academic year 1959–60, with five graduate fellows. The objective is to equip experienced health physicists for new and major responsibilities in a field of increasing complexity. Including the 5 fellows appointed for 1962–63 and 7 renewals, 12 health physicists are now receiving this specialized training.

Industrial hygiene fellowships were awarded to eight fellows for the academic year 1962–63, bringing the total number awarded to 70. The participating universities include: the University of Michigan, the University of Pittsburgh, Harvard University, the University of Cincinnati, and Wayne State University.

Fellowships for graduate training in industrial medicine were awarded to six physicians for the academic year 1962–63. Two

[23] All AEC fellowships are administered by the Oak Ridge Institute of Nuclear Studies (ORINS) except the program for industrial medicine, which is administered by the University of Rochester.

additional fellows were awarded a second year of training. The fellows are at the medical schools of Pittsburgh, Yale, Rochester and Harvard Universities. Seventy-six fellowships have been awarded under this program.

Operation of Courses

Radioisotopes Training Courses

Four series of 4-week basic courses were presented to 203 participants at the training facilities of the Oak Ridge Institute of Nuclear Studies (ORINS) during 1962.

In addition to these basic courses, there were a number of courses offered sequentially to these courses, which included 17 participants in engineering applications, and 69 in advanced radioisotope and research techniques.

During the summer, a 6-week course in isotope technology was offered for 23 small college teachers of chemistry and physics. Also given was a 7-week institute in radiation biology (slanted toward ecology). Twelve high school teachers were included in the summer basic course as an advanced radiation biology institute. In addition to these, an 8-week course was offered for physics teachers of small colleges; included in this was a portion on radioisotope techniques. A special course in activation analysis was also given, in which 23 people participated.

Twelve small-college campuses were visited by the mobile radioisotope training laboratory out of 66 requests for visits. These 2-week courses bring specialized equipment and training that is not normally available to small schools, and have been instrumental in assisting and planning training programs appropriate for these colleges.

Science Demonstration Lecture Program

This program, administered for the Commission by the Oak Ridge Institute of Nuclear Studies, is designed to stimulate interest and competence in science teaching among high school teachers, educational consultants, supervisors and foreign country educators. Through a series of formal lectures, laboratory experiments, conferences and tours of AEC installations, participants acquire a working knowledge of the most recent scientific developments which they introduce into the scientific programs of schools in their respective areas. Two training sessions of 10–12 weeks each were conducted during 1962. Since inception of the program in 1956, 185 participants have received training.

Medical Qualifications Courses

These courses, associated with the ORINS Cancer Research Program, will now be conducted by the Special Training Division at ORINS. They provide registered physicians with instructions in the use of radioactive materials in the diagnosis and treatment of disease which enables them to be licensed for the use of radioactive isotopes.

ANL Seminars

Argonne National Laboratory is conducting a series of monthly seminars in physics and mathematics for junior and senior science students and faculty members of Chicago's west suburban colleges. The meetings were begun in October 1962 and will be continued through May 1963.

Radiobiology Lecture Series

This program for colleges and high schools is administered for the Commission by the American Institute of Biologoical Sciences and is designed to assist in stimulating an interest in biology as a career among students, and to present modern trends and developments in the biological sciences. During the past year 26 speakers visited 64 high school and college campuses.

MEND Program

During the past 3 years, the American Institute of Biological Sciences has administered for the Commission and MEND (Medical Education for National Defense) a visiting lecturers program concerned with the aspects of radiation biology related to national defense. This year, distinguished lecturers visited selected university medical schools throughout the country.

Faculty Participation at AEC Sites

The Commission encourages university faculty members to accept temporary appointments at Commission sites to work on nuclear science and engineering projects oriented toward Commission missions, but with the primary purpose of enhancing the faculty member's scientific background and improving his university's nuclear education capabilities. These projects utilized Commission facilities not available on the faculty member's own campus. This program keeps faculty members up to date on advances in nuclear technology and benefits Commission laboratories by providing a constant infusion of new ideas. Frequently, these temporary appointments are followed

by appointment of faculty members as laboratory consultants, and by contracts for performing Commission research projects on college campuses. At Oak Ridge National Laboratory, 52 university faculty members were employed during the summer of 1962 as research participants and 34 were employed as temporary ORNL summer employees. Approximately 112 faculty members from 68 U.S. universities received temporary appointments at Argonne National Laboratory, and a number of faculty personnel from Rocky Mountain area institutions participated in work at the National Reactor Testing Station in Idaho for both the Commission proper and its contractors.

University-National Laboratory Cooperative Program

In keeping with the Commission's policy to continue and improve the inter-relationships of American universities and the national laboratories, definite progress is being made.

ANL–AMU

The Associated Midwest Universities (AMU), a nonprofit corporation composed of 32 midwestern educational institutions, is under contract to the AEC and has responsibility for promoting participation of faculty and students from educational institutions in a nuclear sciences and engineering participation program at the Argonne National Laboratory (ANL). This permits the use of ANL's unique facilities by university faculty and students and an exchange of scientific information of mutual interest. Major areas of cooperation during 1962 included:

1. University use of the equipment of the International Institute of Nuclear Science and Engineering (IINSE): graduate students from universities were accompanied to ANL by their faculty and received instruction in performing laboratory experiments at ANL.
2. University use of ANL facilities: of particular note is the university use of ANL's heat transfer laboratory; during 1962 there were 17 temporary appointments in the Heat Laboratory including three persons with M.S. or Ph. D. degrees who performed thesis work.
3. AMU–ANL Faculty-Student Conference on Nuclear Engineering: Approximately 70 faculty members and graduate students from 18 midwest universities attended a 2-week conference at ANL in September 1962. The conference was the first of its kind sponsored by the Associated Midwest Universities in cooperation with Argonne.
4. AMU–ANL annual Nuclear Engineering Conference: the third such conference was held January 29–30 at ANL with 100 AMU and 25 ANL participants in the 2-day session.

5. Seminar speakers program: 150 ANL staff members gave seminar talks at universities and a like number of speakers from the University Community visited ANL.

ORNL–ORINS

The Oak Ridge National Laboratory (ORNL)—Oak Ridge Institute of Nuclear Sciences (ORINS) program makes available to university faculty, graduate students, and selected undergraduates the unique opportunities for research found in ORNL and other AEC installations in Oak Ridge. Participants from universities and colleges throughout the United States are, through this program, not only developing a better comprehension of research methods and their significance, but also are making major contributions both to the Commission and to the universities.

In the summer of 1962, there were 54 research participants representing 43 colleges and universities in 19 States. Since its inception, 671 faculty members from 176 colleges and universities in 38 States, Puerto Rico, and the District of Columbia have engaged in research under the Oak Ridge Research Participation program. In the Oak Ridge Graduate Fellowship program there were 16 Fellows in 1962. Eighty-six Fellows have been appointed to this program since its inception. In the summer of 1962, 44 college students, having completed their junior year, worked in the Oak Ridge laboratories under direction of a senior scientific staff, thus bringing to a total of more than 120 the number of undergraduates who have participated in this program since its beginning in 1960.

ANL–ACM "Argonne Semester"

Twenty-four junior and senior students in science completed a semester of study and research at Argonne National Laboratory during 1962. The "Argonne Semester" was instituted in 1960 by Argonne and the ten Associated Colleges of the Midwest (ACM).

Argonne Accelerator Users Group

Physicists from universities and research establishments in the United States and in Europe attended the 8th and 9th in a series of semiannual conferences to develop plans for using the Zero Gradient Synchrotron (ZGS), nearing completion at Argonne National Laboratory. The scientists, members of the Argonne Accelerator Users Group, met at Argonne May 11 and 12 and November 9 and 10.

Midwest Theoretical Physics Conference

The 1962 Midwest Theoretical Physics Conference was held at Argonne on June 1 and 2. Over 200 representatives from universities throughout the United States attended the meeting.

Midwest Theorists' Nuclear Structure Meeting

Twenty university faculty members attended the Midwest Theorists' Nuclear Structure Meeting at Argonne on October 12–13. Participants discussed three subjects: Reactions, Relations Between Reactions and Structure, and Nuclear Structure.

Symposium on Current Trends in Nuclear Power

A joint University of Arizona-Argonne National Laboratory Symposium on "Current Trends in Nuclear Power" was held in Tucson on February 26 through March 2. About 100 scientists, engineers, and technical administrative personnel from universities, research laboratories, and industrial organizations attended the meeting.

International Symposium

An International Symposium on Implications of Organic Peroxides on Radiobiology was held at Argonne National Laboratory May 7–9, 1962. The meeting was sponsored by Argonne's Biological and Medical Research Division in cooperation with the Commission. Approximately 100 visitors, including radiation chemists and biochemists, from at least 6 countries attended the symposium.

College Science Day Program

Approximately 70 deans, chairmen of science departments, and representatives of student science organizations from 9 Chicago area colleges attended a College Science Day Program at Argonne National Laboratory on March 31, 1962. The purpose of the program was to acquaint the participants with Argonne's activities in basic research and engineering development; to create interest in science education; and to call attention to opportunities in science.

Other Activities

Other nuclear education activities essential to fulfill the various technical needs of government, educational institutions, and industrial organizations include short courses and seminars in specialized

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subjects; illustrated slides; lecture films; brochures and booklets; newsletters; curricula development; preparation of texts and laboratory teaching manuals; participation with the Bureau of Labor Statistics, National Science Foundation, and other Federal agencies in surveying scientific and engineering manpower resources and needs; and meetings and conferences covering technical areas. Significant items in this category include:

1. A series of five 16 mm black and white video-taped lecture films under the title, "Understanding the Atom", have been produced and released for high school or college level science courses and for instructional television. (Details on this film series as well as Argonne National Laboratory's "Challenge" series are included under the "Information Programs" section of Part Four.)
2. A two-volume set of radiation training experiments have been made available to the public. They are designed to improve senior-level college and university chemistry courses by providing the student with a fundamental knowledge of radiation as a new processing tool and an understanding of radiation effects on chemical and biological systems. Contracts have been negotiated for the preparation of additional manuals in nuclear technology.

International Training

As a part of its participation in international activities, the Commission—through its Division of International Affairs—sponsors school and on-the-job training for foreign nationals.

Students and Guests at U.S. Facilities

Foreign student enrollment during 1961 and 1962 to formal training courses sponsored by the Commission were:

	Foreign Students		*Countries Represented*	
	1961	*1962*	*1961*	*1962*
Oak Ridge Institute of Nuclear Studies	53	42	20	23
International Institute of Nuclear Science and Engineering at Argonne National Laboratory	109	93	23	18
Puerto Rico Nuclear Center	26	23	12	10
All Other	46	33	6	4

Foreign guest assignments for individual on-the-job training at Commission contractor-operated installations during 1961 and 1962 were:

	Foreign Guests		*Countries Represented*	
	1961	*1962*	*1961*	*1962*
Brookhaven National Laboratory	113	135	33	30
Oak Ridge National Laboratory	108	92	27	22
Argonne National Laboratory	42	20	18	12
Lawrence Radiation Laboratory (Berkeley)	94	83	29	31
All other facilities	53	67	27	28

Industrial and Vocational Training

Firefighters' Training Course

In 1962 the Commission continued to sponsor series of intensive 5-day training courses for firefighter personnel. The course material emphasizes the potential peacetime hazards characteristic of nuclear radiation. The instruction centers about a set of published documents jointly prepared during 1961 by the Commission and the U.S. Department of Health, Education, and Welfare.[24]

Since October 1961, a number of States, through their industrial and vocational training organizations, have availed themselves of the opportunity to have firefighting personnel receive nuclear radiation instruction. The States are: California, Oregon, New York, Virginia, Wisconsin, Michigan, Louisiana, Alabama, Delaware, North Carolina, and Pennsylvania. In all, 293 State-recommended fire instructors, representing these 11 States, have received training. These instructed personnel are now qualified to train other members of the fire service, situated in their home State in the basic aspects of nuclear energy and its potential adverse effects on people in connection with fires and various kinds of accidents.

Broadening Manpower Resources

During 1962, the Commission restated [25] its policy of: (*a*) encouraging the temporary employment of academic participants and providing research and other nuclear work experience for noncontractor employees; (*b*) supporting cost-type contractor training programs;

[24] See page 288, "Annual Report to Congress for 1961."

[25] By revising AEC manual chapter 4204—Employee Training and Nuclear Manpower Sources.

and (*c*) encouraging participation in apprenticeship programs. Programs carried on under this policy are designed to help in providing a well trained and competent contractor work force; broaden the base of manpower resources for atomic energy growth and development; and increase the potential in the research effort through the fresh ideas of graduate students and the revitalization which academic association brings to the working scientist.

CONTRACTING POLICY

Indemnification of AEC's Contractors

In the past, AEC policy has limited availability of Price-Anderson indemnification to those contractors who were engaged in the construction or operation of production or utilization facilities, or in other activities involving the risk of occurrence of a substantial nuclear incident.

Although the Price-Anderson Act permitted the indemnification of contractors whose only risk was one of liability for a substantial nuclear incident stemming from having supplied a faulty product, design, or service, this authority had not been exercised. Normally those contractors would be protected under the umbrella-type indemnity agreement covering the production or utilization facility in which their products or design are incorporated. In some cases, however, these contractors deliver products that do not find their way into an indemnified facility, *e.g.*, contractors whose products are incorporated into atomic weapons, contractors who produce fuel elements used in naval submarines. These contractors are exposed to the risk of public liability for a substantial nuclear incident and, to the extent that they are not indemnified against that liability, the public may lack protection against the damages that would result from such an incident.

During fiscal year 1962, the Commission revised its policy in order to fill that gap. Price-Anderson indemnification will now be made available to those AEC contractors whose only risk is one of products liability. The indemnification will take the form of either a Price-Anderson indemnity agreement or a contractual assurance that the contractor will be indemnified under the Price-Anderson indemnity agreement extended to another AEC contractor.

Also, the Commission revised its policy to implement the recent amendments to the Atomic Energy Act providing coverage for nuclear liability outside the United States, so long as the incident involves a

facility or device owned by, and used by, or under contract with the United States. This coverage also extends to the subcontracts and purchase orders under AEC prime contracts.

Standard Contract Forms for Research

In an effort to standardize and simplify the numerous contracts with educational institutions for basic research, the Commission, during the past year, held several meetings with university officials and interested contracting personnel throughout the AEC complex. After these discussions, model contracts for use in connection with basic research conducted for the AEC by colleges and universities were developed along with standardized procedures applicable to the handling of these arrangements. The Commission now has model contracts in use both for the small fixed-price arrangements and the somewhat larger cost-type arrangements.

Small Business

During fiscal year 1962, small business received a substantially increased share of the total Commission subcontract awards, totaling $338.0 million or 45.9 percent of the $736.0 million total subcontract awards. By comparison, the small business share for the fiscal year 1961 was 41.4 percent and for the period 1951–61 was 39.3 percent.

Maximum practicable small business participation under the Commission's prime contracts and subcontracts continued to receive emphasis at the Commission's Operations Offices and by each cost-type contractor purchasing officer.

AEC Procurement Regulations, implementing Federal Procurement Regulations to strengthen the subcontracting small business program for all executive agencies were issued during 1962.

Small firm inventory. The Commission's 13 major field offices cooperated with the Small Business Administration in distributing SBA's facilities inventory registration forms to interested small firms. SBA's facilities inventory is a nationwide listing of small firms and their productive facilities. Its purpose is to provide an up-to-date reference source for government purchasing agencies which award prime contracts, and to make available to prime contractors adequate information on small firms equipped to handle subcontracts. The listing would also provide valuable data on small firms in case of a national emergency.

Procurement and Contract Training

During the year, the AEC initiated a series of procurement and contract training sessions conducted at the principal Field Offices, to assure that procurement and contracting policies are understood by all of the Field Office staff who have interests and responsibilities in the procurement and contracting area.



Pre-proposal conference. In August, the Commission issued a modified third-round invitation for proposals from industry to participate in the design, construction, and operation of a large-scale (at least 400,000 gross electrical kilowatts) nuclear powerplant. Photo shows part of the large number of industrial representatives who attended a meeting in the AEC's Headquarters auditorium at which the details of the invitation were discussed and the terms under which contracts would be negotiated. The meeting was sponsored by the Commission's Division of Contracts and Division of Reactor Development.

INDUSTRIAL RELATIONS

During 1962, a study of employment trends by type of establishment showed that the combined number of scientists and engineers working in the atomic energy field increased 58 percent between 1956 and 1961. As a whole, the latest figures for overall employment in the nuclear fields showed an increase from previous manpower surveys. During the year the Commission's contractors, recognizing the opportunities of a labor market expanded by the utilization of minority groups previously excluded, continued to implement the Commission's long standing policy of nondiscrimination in employment.

MANPOWER FOR ATOMIC ENERGY

The civilian work force of some 172,000 employees actually employed in atomic energy work is distributed throughout a wide diversity of economic activities. Rather than being an industry,[26] the atomic energy field cuts across a number of major industrial groups including among others: mining of non-metallic minerals, chemicals manufacturing, ordnance manufacturing, building construction, and electric services. Also the atomic energy field is represented by employment in such activities as: Federally owned research and development laboratories operated by either educational institutions or industrial firms; private, independently financed research and development organizations; and governmental agencies. Recognition of these relationships leads to a better understanding of the meaning and uses of atomic energy manpower statistics.

The manpower data described in this section of the Annual Report refer to those personnel engaged in functions exclusively and directly devoted to the development and production of atomic energy as an economic resource. Hence, the data exclude those persons whose activities are connected with such actual applications of nuclear energy as: transmission and consumption of electricity; operation of nuclear ships; use of radioisotopes merely as a tool in medical or dental practice, in agricultural or industrial processes, or in some form of nonnuclear research.

[26] The atomic energy field is not an "industry" as this term is customarily used for classification purposes. The Standard Industrial Classification Manual (Executive Office of the President, Bureau of the Budget, p. 431, 1957), which is used by the Federal Government and other organizations in the classification of establishments by type of activity in which engaged, defines an industry as "a grouping of establishments primarily engaged in the same or similar lines of economic activity." Taking manufacturing industries as an example, "the line of activity is generally defined in terms of the product made, materials consumed, or process of manufacture used." The atomic energy field, rather than being an industry in the accepted sense, includes establishments in many different industries.

Industrial Employment

In 1962, industrial establishments employed about 128,000 persons actually engaged in atomic energy work according to the Commission-sponsored Bureau of Labor Statistics survey. Covered by the study were 422 establishments of which 51 were government-owned but contractor operated (GOCO). The remaining 371 establishments were privately-owned and operated plants.

An establishment was instructed to include in its survey report all personnel employed in the unit regardless of whether they were engaged in atomic energy work or other types of employment. This instruction was necessitated by the fact that the Commission's study in 1962, as in 1960 and 1961, was coordinated with the much larger Bureau of Labor Statistics' annual survey of scientific and technical manpower in American industry, a survey which counts employment on an establishment-wide basis. To secure information on actual employment in the atomic energy field, as distinct from over-all establishment employment, reporting units were asked in 1962, for the first time, to indicate the percentage of total employment devoted to atomic energy activities.

These percentages provided the means whereby estimates were derived of number of persons performing atomic energy work in 1962. For the GOCO establishments, 51 in all, 99 percent of the employment was in the atomic energy field. But for the privately owned firms, 371 in all, only 26 percent of the personnel actually performed atomic energy work. Included in the group of 371 establishments were 179 firms each of which had employment in the atomic energy field of less than 50 percent of their total staff. For this group, the average proportion in which atomic energy workers were among all workers considered was only 6.6 percent. The corresponding percentage for the remaining 192 private firms was 92 percent.

Table 8 provides data on the distribution of establishment employment by occupation and primary function for the 192 privately-owned firms having 50 percent or more of their workers in atomic energy endeavors, and separate data for the 51 GOCO's. Total employment for the privately-owned firms was virtually the same in 1961 and 1962, close to 25,000; for the GOCO's there was an increase of about 3,000. Table 9 shows the estimated number of persons actually working in the atomic energy field in January 1961 and 1962 classified by economic segment in which employed. Also listed are the number of GOCO, and of privately-owned, firms in each segment.

Federal Service Employment

According to U.S. Civil Service Commission data, collected at the request of the AEC, the total number of Government personnel working in atomic energy research and development on October 31, 1961, was 2,171 of which 642 were in the Atomic Energy Commission. Eleven Federal agencies besides the Commission are represented with the Navy, National Aeronautics and Space Administration, and the Army reporting 552, 320, and 238 research and development workers respectively in the atomic energy field. Some 8,000 persons were employed throughout the Federal service in all kinds of atomic energy activities in January 1962.

All Other Employment

The following tabulation summarizes the estimates for employment in atomic energy work exclusive of that already described:

TABLE No. 8.—INDUSTRIAL EMPLOYMENT IN 51 GOVERNMENT-OWNED CONTRACTOR-OPERATED ESTABLISHMENTS (GOVT.) AND 192 PRIVATELY OWNED ESTABLISHMENTS (PVT.) PRIMARILY ENGAGED* IN ATOMIC ENERGY WORK, JANUARY 1962

[Preliminary Data]

OCCUPATIONS	PRIMARY FUNCTIONS											
	TOTAL EMPLOYED IN ALL FUNCTIONS		PERFORMANCE OF RESEARCH-DEVELOPMENT		MANAGEMENT AND ADMINISTRATION OF RESEARCH-DEVELOPMENT		MANAGEMENT AND ADMINISTRATION OTHER THAN RESERACH-DEVELOPMENT		PRODUCTION AND OPERATIONS		ALL OTHER ACTIVITIES	
	Government	*Private*	*Government*	*Private*	*Government*	*Private*	*Government*	*Private*	*Government*	*Private*	*Government*	*Private*
Total all employees	101,442	24,724	26,010	3,833	3,899	606	5,387	2,286	48,997	13,123	17,149	4,876
Total Engineers	11,910	3,756	6,843	1,780	764	326	472	327	3,414	887	417	436
Aeronautical engineers	84	35	71	29	8	5	2	0	2	0	1	1
Chemical engineers	1,957	340	1,089	181	105	37	82	35	640	67	41	20
Civil engineers (architectural, construction, structural, sanitary, etc.)	577	256	188	33	12	14	42	68	216	91	119	50
Electrical and electronic engineers	2,759	783	1,780	327	161	69	84	49	684	214	50	124
Mechanical engineers	3,554	1,313	2,058	690	279	127	146	98	1,014	313	57	85
Metallurgical engineers	560	237	397	126	73	20	9	32	67	50	14	9
Reactor engineers	786	412	599	332	95	33	13	10	79	27	0	10
Other engineers	1,633	380	661	62	31	21	94	35	712	125	135	137

Total Scientists	8,449	1,269	6,393	732	703	108	135	105	1,047	265	171	59
Chemists	2,905	419	2,028	195	223	28	59	44	576	139	19	13
Physicists	2,778	451	2,215	348	320	51	17	14	204	18	22	20
Health physicists	379	76	200	21	29	8	23	14	110	29	17	4
Metallurgists	448	101	383	76	41	9	4	4	13	9	7	3
Geologists and geophysicists	8	63	6	4	0	0	0	9	2	48	0	2
Mathematicians	863	124	652	75	44	10	17	18	93	15	57	6
Medical scientists (exclude practitioners)	156	5	107	1	12	1	10	1	18	2	9	0
Agricultrual scientists	10	0	5	0	0	0	1	0	4	0	0	0
Biological scientists	460	8	401	4	32	1	1	0	21	1	5	2
Other scientists	442	22	396	8	2	0	3	1	6	4	35	9
Total Technicians	14,534	2,933	9,158	1,103	116	9	84	7	4,422	1,596	754	218
Draftsmen	2,053	822	1,053	367	5	6	9	4	878	375	108	70
Electronic technicians	2,025	385	1,392	167	6	0	14	1	468	180	145	37
Instrument technicians	1,072	171	746	46	34	0	14	0	237	112	41	13
Radiographers	115	24	36	3	2	0	0	0	67	21	10	0
Other engineering and physical science technicians	6,496	666	4,878	398	52	2	5	0	1,429	230	132	36
Health physics technicians (include radiation monitors)	979	137	132	18	2	0	23	0	657	110	165	9
Medical, agricultural, and biological technicians	565	33	411	8	12	0	9	0	48	24	85	1
Other technicians	1,229	695	510	96	3	1	10	2	638	544	68	52
Total Other Professional and Administrative personnel not reported above	9,744	2,055	176	12	730	107	3,296	896	3,798	714	1,744	326
Total Clerical and Other Office Personnel	14,606	3,623	514	113	1,572	46	1,184	724	4,786	1,074	6,550	1,666
Chemical Process Operators	3,281	753	117	6	2	0	0	4	3,162	743	0	0
Nuclear Reactor Operators	959	126	109	48	0	0	12	0	838	78	0	0
Total Skilled Trades (include journeymen only; exclude Chemical Process Operators and Nuclear Reactor Operators	16,345	3,997	1,548	29	10	4	30	107	12,805	2,659	1,952	1,198
Total, All Other Production, Maintenance, and Construction Workers	12,958	5,324	462	4	0	0	77	109	11,398	4,798	1,021	413
Total Service Workers	8,656	888	690	6	2	6	97	7	3,327	309	4,540	560

*Each establishment employed 50 percent or more of its total staff in the atomic energy field.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

Sector of Atomic Energy Field	*Number Employed*
Uranium mining including supporting personnel	*7,200
Private nonindustrial and noneducational research and development laboratories	1,800
Construction of nuclear facilities	12,300
University and college research and teaching, including supporting personnel	14,000
Total	35,300

*Personnel engaged in mining only amounted to 4,300.

TABLE NO. 9.—ESTIMATED [1] NUMBER OF EMPLOYEES ACTUALLY EMPLOYED IN ATOMIC ENERGY WORK, BY ECONOMIC SEGMENT AND BY TYPE OF ESTABLISHMENT OWNERSHIP, JANUARY 1961 and 1962 (Preliminary Data)

Economic Segment	Number of Establishments		Total Employment			
			1961		1962	
	Govt.	Pvt.	Govt.	Pvt.	Govt.	Pvt.
Commission laboratory and research facilities	20	------	41,275	------	42,038	------
Atomic energy defense production facilities	14	9	36,652	2,391	38,465	1,544
Production of feed materials	6	6	11,346	522	9,277	538
Reactor and reactor component design and mfg	(2)	38	(2)	7,992	(2)	7,966
Uranium milling	------	23	------	4,793	------	4,286
Nuclear instrument manufacturing	------	106	------	3,717	------	4,237
Design and engineering of nuclear facilities	------	26	------	2,157	------	2,492
Prod. of special materials for use in reactors	(2)	15	(2)	1,970	(2)	1,890
Private research laboratories	------	49	------	1,178	------	1,179
Particle accelerator manufacturing	------	5	------	808	------	883
Fuel element fabrication and recovery activities	(2)	6	(2)	506	(2)	786
Processing and packaging radioisotopes	------	21	------	215	------	291
Power reactor operation and maintenance	4	6	341	227	383	250
Radioactive waste disposal	------	4	------	51	------	44
Miscellaneous activities	7	57	7,420	1,920	9,867	1,900
Total	51	371	97,034	28,447	100,030	28,286

[1] Based on reported percentage of total employment, in each establishment, actually performing atomic energy work.

[2] Data included in miscellaneous activities segment because less than three establishments were reported in each of these segments.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

Scientist-Engineer Employment Trend

A marked characteristic of the atomic energy field is its dependence on scientific research and experimentation. About one out of every five employees in the atomic energy field is either an engineer or a scientist. Because of the importance of these occupations, it is of interest to note the trend in employment between 1956 and 1961 of scientists and engineers combined. The comparison is made in terms of four significant economic components of the field.

Table 10 shows the trend in employment of nuclear scientists and engineers combined, by types of establishment, for the years 1956 and 1961. Scientists and engineers working for the Government-owned establishments operated by either industrial firms or universities increased in greatest numbers, both in absolute amounts and percentage change during the 5-year period. In addition to the 1956–61 percentage increases, Table 10 presents the percent distribution of scientists and engineers by type of establishment for 1956 and 1961. For the nuclear science field as a whole, there were 15,700 more scientists and engineers by 1961—a growth of 58 percent.

Occupational Opportunities in Atomic Energy

A 50-page bulletin designed to help young people find jobs in the field of atomic energy was issued in May 1962. The brochure, entitled "Employment Opportunities in the Atomic Energy Field" (TID–14314),[27] was prepared for the Commission by the Bureau of Labor Statistics of the U.S. Department of Labor. Demand for the publication has been consistently strong and enthusiastic.

In addition to general information on the nature of employment in the atomic energy field, the bulletin contains a detailed list of skilled occupations, broken down into three categories: scientists and engineers, technicians and other technical personnel, and skilled workers. The education and experience required for each of the three categories is explained. Six detailed employment tables, 14 photographs, and a bibliography on atomic energy are also contained in the brochure.

TABLE NO. 10.—TREND IN EMPLOYMENT OF NUCLEAR SCIENTISTS AND ENGINEERS, 1956–61

NUMBER OF INDIVIDUALS

Type of Establishment	1956		1961		Percent Increase in Number of Individuals
	Number of Scientists & Engineers	Percent Distribution	Number of Scientists & Engineers	Percent Distribution	
Govt.-owned, industry- or university-operated facilities	12,800	47.4	22,300	52.2	74.2
Privately owned industrial and other firms*	8,100	30.0	11,500	26.9	42.0
Educational institutions	4,700	17.4	7,000	16.4	48.9
Federal service	1,400	5.2	1,900	4.5	35.7
Total	27,000	100.0	42,700	100.0	58.1

*Comprises industrial, mining, and construction establishments, as well as those privately owned independently financed research and development organizations not a part of an educational institution.

[27] Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., $0.50.

A major feature of the bulletin is an explanation of how to proceed to locate employment in the atomic energy field. To guide the job seeker, the brochure also lists some typical establishments, in each of 16 different economic segments, employing atomic energy workers. Although the bulletin focuses attention on the needs of younger people, it is valuable to persons of any age interested in a job in the atomic energy field.

Equal Employment Opportunity Program

As a step toward furthering the implementation of the President's "equal employment opportunity" Executive Order of March 1961, the Commission, during February 1962, installed a reporting system requiring "Reports on Compliance With Non-Discrimination Contract Provisions" to be submitted by each AEC field office on a quarterly basis. From these reports, the Commission is able to note the progress of its contractors toward the goal of equal employment opportunities without regard to race, creed, color, or national origin and assist the contractors toward that goal. Reaching this goal also provides the contractor with an expanded labor market from which to choose his personnel.

As of the end of November 1962, seven complaints had been filed against Commission contractors during the calendar year. Of these, two cases had been processed and referred to the President's Committee on Equal Employment Opportunity. The others are still being investigated.

In the interest of reaching full and continuing effectiveness in the shortest possible time, the Commission has added to its Headquarters staff an Intergroup Relations Specialist. He will serve as principal staff assistant and advisor in providing technical guidance on the implementation of the Equal Employment Opportunity program.

Contractor Employment

The composite work force of Commission contractors engaged in operations, research, development, maintenance, and service has increased about five percent since December 1961.

In September 1962, the total employment of the 31 prime cost-type contractors operating 41 Commission installations was 96,091 compared to 91,538 employed by 30 contractors in December 1961. Two groups of employees perform duties which meet the requirements of the Fair Labor Standards Act (FLSA) for inclusion under the overtime pay provisions—production and related (manual), and clerical and related (nonmanual). Employees exempt from the FLSA over-

time pay provisions are those employed in a bona fide executive, administrative, or professional capacity.

Total "exempt" employment increased 3.1 percent during the first 9 months of 1962 and in September accounted for 32.5 percent of the total work force. Revised reporting requirements, effective in July 1962, included the identification of the scientific staff among contractors employing more than 50 persons at AEC installations. These reports show that in September the exempt group of employees consisted of 49.6 percent for nonsupervisory scientists and engineers and 50.4 percent for all other executive, administrative, and professional employees (including scientists and engineers who are supervisors).

The "nonexempt" portion of the work force is composed of 64.8 percent production and related, and 35.2 percent clerical and related. Increased employment of these groups from December 1961, through September 1962 amounted to 5.9 percent.

Collective Bargaining Activities

Approximately 31,000 or 22.0 percent of the total nonexempt work force employed by 31 prime cost-type contractors operating 41 Commission-owned installations (excluding construction contractors) are represented by labor organizations under 70 collective bargaining agreements. The distribution of the labor unions and employee representation is shown in Table 11, below.

TABLE NO. 11.—LABOR UNION REPRESENTATION

Organization	Approximate Representation	Percent
Metal Trades Councils (AFL–CIO)	13, 090	42. 2
International Association of Machinists (AFL–CIO)	6, 926	22. 3
Oil, Chemical and Atomic Workers International Union (AFL–CIO)	3, 740	12. 0
Miscellaneous Unions (excluding guards, but including crafts, etc.)	3, 978	12. 8
Miscellaneous Guards Unions (Independent)	1, 490	4. 8
Office Employees International Union (AFL–CIO)	1, 826	5. 9
	31, 050	100. 0

During 1962, 36 of the 70 agreements covering approximately 12,000 employees were either negotiated initially, renegotiated upon expiration of their terms, or modified pursuant to wage or other reopening provisions. In all but five instances, affecting five contractors and approximately 4,000 employees, negotiations were concluded without

resort to work stoppages. In the event of failure of the parties to negotiate their differences, the Atomic Energy Labor Management Relations Panel (AELMRP) may intervene in the interest of furthering the peaceful processes of collective bargaining and of assuring continuity of operations.

The Panel took jurisdiction in nine instances and as of October 29, 1962, made recommendations in seven instances in which the parties were unable to resolve their differences by negotiations. The contractors, labor organizations and bargaining units involved and the date of the Panel's recommendation are set forth below:

Contractor	Union	Unit	Date of Panel Recommendations
Mason & Hanger-Silas Mason, San Antonio, Tex.	Intl. Association of Machinists.	Firemen	May 16, 1962.
Mason & Hanger-Silas Mason, Burlington, Iowa	Intl. Brotherhood of Electrical Workers.	Electricians	July 18, 1962.
	United Assn. of Plumbers & Pipefitters.	Pipefitters	
	Intl. Assn. of Sheet Metal Workers.	Sheet Metal Workers	
Mason & Hanger-Silas Mason, San Antonio, Tex.	Intl. Assn. of Machinists	Production & Maintenance, Clerical & Technical.	October 29, 1962.
Goodyear Atomic Corp., Portsmouth, Ohio.	Oil Chemical & Atomic Workers.	Production & Maintenance.	June 4, 1962.
Dow Chemical Co., Rocky Flats, Colo.	Denver Metal Trades Council.	Production & Maintenance.	June 15, 1962.
Reynolds Elec. & Engrg. Co., Mercury, Nev.	Intl. Brotherhood of Teamsters.	Firemen	September 14, 1962.
Zia Co., Los Alamos, N. Mex.	Intl. Hod Carriers, Bldg. & Common Laborers Union.	Janitors	October 29, 1962.
Union Carbide Nuclear Co., Oak Ridge, Tenn.	Atomic Trades & Labor Council.	Production, Maintenance & Firemen.	Not yet available.
Federal Services, Inc., Mercury, Nev.	International Guards Union of Nevada.	Guards	Not yet available.

Work stoppages, accounting for 541,042 man-hours of lost time or 0.3 percent of the total work hours scheduled among operating, maintenance, and service contractors occurred in labor disputes involving Mason & Hanger-Silas Mason Co., Burlington, Iowa; Dow Chemical Co., Rocky Flats, Colo.; Reynolds Elec. & Engrg. (Firemen), Mercury, Nev.; and Zia Co., Los Alamos, N. Mex. In one instance, that involving the Dow Chemical Co., the work stoppage occurred after the Panel had made its recommendation. In all other cases the stoppages were terminated upon the Panel's intervention. In the Dow Chemical Co. case the local union membership initially refused to accept the Panel's recommendation and were on strike from August 11 until September 7, 1962. Work was resumed following union membership acceptance of a negotiated settlement substantially in accord with the Panel's recommendation.

Idleness during the year as a result of work stoppages in construction activities accounted for 1.1 percent of the scheduled work time. These work stoppages grew out of such issues as: labor agreement terms, jurisdictional disputes between crafts, and work assignments.

Compensation for Employees

Procurement Regulations

On August 21, AEC Procurement Regulation (AECPR) Subpart 9–15.5014–14, "Compensation for Personal Services," was revised to (*a*) incorporate certain general standards for use by the AEC in assuring that compensation paid cost-type contractor employees meets the tests of reasonableness; (*b*) require prior AEC approval in each instance where it is proposed to seek reimbursement for the cost of compensating individual contractor employees at an annual rate of total compensation of $25,000 or more; and (*c*) prescribe other circumstances under which contracts may provide for AEC prior approval of compensation paid individual employees. The requirement for AEC approval of compensation of $25,000 per annum or greater is consistent with one of the recommendations of the April 30, 1962, "Report to the President on Government Contracting for Research and Development." The report was prepared by a special interdepartmental committee established by the President and headed by the Director of the Bureau of the Budget.

Contractor Employee Salaries

During the first half of 1962, exempt personnel [28] of the 31 prime cost-type contractors averaged $869 in base monthly earnings.

In the revision of the reporting requirements concerning contractor personnel and industrial relations activities, the monthly report of employment, hours, earnings, and turnover data was refined to identify the scientific and engineering segment of the exempt work force.

In September 1962, after conversion to the new reporting requirement, reports from 31 prime contractors showed that the total exempt work force averaged $878 in base monthly earnings. For the nonsupervisory scientists and engineers, the average base salary was $858 per month. For the remaining personnel in the exempt work force the average base monthly salary was $896.

[28] "Exempt personnel" consist of all those persons employed in a bona-fide executive, administrative, or professional capacity who are exempt from the overtime pay provisions of the Fair Labor Standards Act. "Non-exempt personnel" consist of all manual and nonmanual employees performing duties which meet the requirements for inclusion under the overtime pay provisions of the Fair Labor Standards Act.

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Average earnings for office and clerical employees remained fairly constant during 1962. Average pay for these employees has increased from $2.74 per hour in December 1961, to $2.81 in September 1962.

Since 1952, earnings of production and related employees have been compared with those of production workers in industrial establishments considered most comparable in product processes; namely, Products of Petroleum and Coal and Industrial Inorganic Chemicals. Between 1952 and 1961, the annual average of straight-time hourly earnings for the Commission's contractor production and related employees had maintained a position between the two industries.

During the past year, the Bureau of Labor Statistics shifted to the 1957 Standard Industrial Classification (the most recent system). This change introduced new elements of comparison between earnings in the atomic energy field and those in petroleum and chemicals and influenced their current relative positions. The classification revision, in part, accounts for the current changed relationships among the three categories of earnings. Under the new series, for example, the straight-time pay per hour in September 1962 averaged $3.07 for Commission contractors, $2.98 for petroleum refining and related industries, and $2.89 for industrial chemicals. This is the latest month for which data are available.

Labor-Management Advisory Committee

In March 1962, the AEC established a Labor-Management Advisory Committee of representatives of organized labor and of employers in the civilian atomic energy field. The purpose of the committee is to bring together representatives of organized labor with representatives of management and the AEC to discuss general problems, procedures, and requirements in connection with the radiological aspects of industrial safety. Agenda items to date have been concerned primarily with problems in the licensee area.

Labor Members

The labor members are Peter T. Schoemann, Washington, D.C., President, United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada; Gordon M. Freeman, President, International Brotherhood of Electrical Workers, Washington, D.C.; Albert J. Hayes, President, International Association of Machinists, AFL–CIO, Washington, D.C.; Elwood Swisher, Vice-President, Oil Chemical and Atomic Workers International Union, Denver, Colo.; and Andrew J. Biemiller, Legislative Representative, AFL–CIO, Washington, D.C.

Management Members

The management members are Harold Fidler, Associate Director, Lawrence Radiation Laboratory, University of California, Berkeley; Roger J. Coe, Vice-President, Yankee Atomic Electric Co., Boston, Mass.; Logan B. Emlet, Executive Vice-President, Union Carbide Nuclear Co., New York; Charles D. Harrington, Vice-President, United Nuclear Corp., St. Louis, Mo.; and Homer Myers, Spindletop Research Center, Lexington, Ky.

Oscar S. Smith, Director of the Commission's Division of Labor Relations, is chairman of the committee and Robert Lowenstein, Director of the AEC's Division of Licensing and Regulation, serves as vice-chairman.

Nevada Test and Space Site Construction Labor Board

In August 1962, the Nevada Test and Space Site Construction Labor Board was created by joint action of the Chairman of the Missile Sites Labor Commission and the Chairman of the Atomic Energy Commission to review (*a*) questions concerning uneconomical labor practices, and (*b*) continuity of work at the Commission's Nevada Test Site (NTS), including the joint AEC–NASA Nuclear Rocket Development Station.

The Board, composed of a five-man tripartite panel, of which James J. Reynolds, Assistant-Secretary of Labor, is Chairman, examines specific questions raised by the Commission concerning uneconomical labor practices involving construction and related activities. This panel holds hearings or devises other appropriate procedures for interested persons to present their views and makes appropriate recommendations to the Atomic Energy Commission.

Labor practices questioned by AEC as uneconomical relate to such matters as: excessive hazard pay practices; cash payment in lieu of benefits; application of construction conditions to nonconstruction work; overtime pay for shifts scheduled for continuous activity; payment of "home to work" travel time; etc.

In addition to reviewing questions of uneconomic practices, the Board may intervene if a labor dispute at NTS is not resolved after mediation efforts by the Federal Mediation and Conciliation Service, and if such dispute results in a strike or a strike is threatened. In this event, the scope of its functions permits it to: arrange appropriate procedures for continued operations, allowing in the meantime for interested parties to present their views; perform mediation functions; and, if necessary, make recommendations to the parties for settlement of the issues.

Workmen's Compensation Standards

Federal Bills

The question of workmen's compensation in relation to radiation injury received particular attention during the year. During Congressional hearings on H.R. 1267 and H.R. 2731, the Secretary of Labor offered, jointly with the Atomic Energy Commission, to develop appropriate recommendations for the House Committee on Education and Labor. These Bills proposed a Federal Radiation Workmen's Compensation Law which dealt with the problems of proof of causation by means of certain legal presumptions.

The Commission cooperated with the Secretary in a review of this matter and concurred with the Secretary in his recommendations to the Committee. These recommendations proposed a series of studies in selected areas, such as causal relation, record keeping, and improved standards for State laws. The report concluded that the genetic effects of ionizing radiation were not to be considered as falling within the area of workmen's compensation.

Cooperation With States

The Commission has also cooperated with the Council of State Governments in activities looking toward improvements in State workmen's compensation laws.

Specifically, the Council's Committee of State Officials on Suggested Legislation established a working committee, on which Commission personnel participated, to draft optimum provisions for a comprehensive Workmen's Compensation and Rehabilitation Law. The substantive provisions of such a law were completed during the year and are part of the Council's Suggested State Legislation Program for 1963. These provisions, as indicated by the title, embrace all facets of workmen's compensation and are not limited to radiation injury. However, in this comprehensive review, radiation injury received considerable attention and the Council's Suggested State Legislation does meet many of the problems related to radiation and identified as present in some existing State legislation. The problem relating to time limitations is not dealt with in the present suggested provisions but will be covered in procedural provisions to be recommended by the Council.

OPERATIONAL SAFETY

During calendar year 1962, the safety and health of Federal and contractor workers in the atomic energy program continued to compare favorably with that achieved in well-managed private industry.

Radiation exposures were well within prescribed operational limits. Production, research and service employee occupational injury rates were reduced slightly. Construction injury rates increased, due largely to accelerations of tunneling, drilling, and general construction work in support of the nuclear weapons test program.

HEALTH AND SAFETY PROGRAMS

Operational Safety Appraisal Program

The Commission continued to stress the use of surveillance and evaluation of the health and safety programs of both the Field Offices and the contractors who operate the production plants and the research laboratories for the AEC. The health and safety management functions of each of 11 Field Offices were formally evaluated during 1962 by the professional staff of the Commission's Division of Operational Safety. Similar appraisals have been made of contractor operations by the Field Offices. Particular emphasis has been placed this year on the review of AEC contractor reactor safety and medical programs.

Reactor Safety Program

A revised version of Atomic Energy Commission Manual Chapter 8401 [29] which deals with the safety of AEC-owned reactors will be issued in early 1963. The purpose of this revision is to clarify the responsibilities and to update the procedures to be employed in the program for the safety of AEC-owned reactors. These revisions are based on the methods employed and the experience gained since previous issues of this chapter.

This Manual Chapter delineates the duties, responsibilities, and authorities of the Managers of Field Offices and Headquarters Divisions with respect to reactor and critical facilities. It establishes the level at which reactor safety decisions can be made and provides for an independent review of proposed construction, startup operation, or modification of a reactor. Procedures for the review and approval of contractor documents (including safety evaluation reports, operating, and maintenance manuals), proposed plans, and modifications are established. In addition, this document charges the Managers of Field Offices with responsibility for periodic surveillance of contractor reactor activities (including direct reactor inspections, contractor review procedures, training and qualification programs) during opera-

[29] The AEC manual is used to publish policy, assign responsibility, delegate authority, establish procedures and standards, and provide guidance to all levels of the AEC organization and its contractors.

tional and construction phases, to be performed by an independent staff of qualified experts.

Field appraisal. All Field Offices have established programs for contractor reactor safety appraisal. The organizational approaches to implementation of the reactor safety programs differ depending on particular circumstances at each Field Office, *e.g.*, staff availability, reactor types and locations, contractor capabilities and experience.

All Field Offices have instituted reactor inspection programs that generally require one formal inspection per year for each reactor. In addition, these programs emphasize the need for several inspections each year for those reactors showing a high activity level, such as a new reactor startup, or significant modification. All field office inspection programs are proceeding satisfactorily and are on schedule. The appraisals consist of direct inspection of the contractors' reactors; logs and records; operating and maintenance procedures; training and qualification programs. Formal inspection reports, including conclusions and recommendations relating to reactor safety matters, are submitted to the contractor and the concerned Headquarters Divisions. Followup action on these recommendations is the function of the Field Office.

Medical Program

During 1962, the Commission formalized an existing policy for contractor guidance in their occupational health programs by publication of AEC Manual Chapter 0528, "Occupational Health Programs". This step was taken to assist contractor management in dealing constructively with employee health by stressing prevention of illness and injuries, as well as the adequate recognition and treatment of occupational disabilities.

Accidents and Radiation Exposure Experience

There were 24 accidents and radiation overexposures in atomic energy facilities from December 1, 1961, to November 30, 1962, inclusive, which are summarized in Table 12. Nineteen of these were of the "A" type,[30] including seven deaths; none involving radiation.

[30] In April 1962, AEC Manual Chapter 0502 "Reporting and Investigating Accidents and Radiation Exposures", was revised. This chapter categorized types of accidents and radiation exposures as follows:

Type A (accidents and radiation exposures) which require immediate notification (see the following table); type B (accidents and radiation exposures) which require reporting within 72 hours (not included in the table); type C (accidents) which require reporting quarterly or annually (not included in the table); the other type includes those radiation exposures which require reporting annually (see footnotes to table 12.)

TABLE No. 12.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]

(December 1, 1961—November 30, 1962)

No.	Date	Operations Office [b] and Contractor	Injuries and Overexposures	Loss	Remarks
[c] 61-33	12-19-61	HA-General Electric Co.	1		Superficial plutonium contamination puncture wound on finger when wire pierced glove while wiring inside of a hood.
[c] 61-36	12-12-61	ID-Phillips Petroleum Co.	0	$16,360	Reactor manually scrammed following fission break caused by restriction of primary coolant flow resulting from remnants of transparent acrylic resin sight box.
[c] 61-37	12- 4-61	BH-Brookhaven National Laboratory.	0	10,850	Fire in biology laboratory; major portion of loss was damaged equipment.
[c] 61-38	4-20-61	HA-General Electric Co.	0	13,000	Uranyl nitrate (1,355 lbs. of depleted uranium) lost to ground when tank trailer was overfilled due to misunderstanding between regular operators and their lunch relief.
[c] 61-39	4-13-61	HA-General Electric Co.	0	12,900	Approximately 30,000 gals. of nitric acid (100%) lost to chemical sewer, as a result of valves being left open.
61-1	1-22-62	SR-E. I. du Pont de Nemours & Co.	1 killed		Carpenter crushed beneath concrete form.
[d] 62-2	2-15-62	SR-E. I. du Pont de Nemours & Co.	0		Purging of stack gas sampling line released contaminated particulates requiring washing of 163 vehicles for decontamination.
62-5	2-21-62	OR-National Lead Co. of Ohio.	2 injured	500	Hydrogen explosion occurred in uranium casting pot while cover was being removed. One employee received severe laceration of head and an eye injury; one a minor shoulder injury.
62-6	3-18-62	OR-Union Carbide Nuclear Co., Paducah Plant.	1 killed 1 injured	15,500	Chemical explosion occurred during routine operations in metal reduction furnace. Two operators 35 feet from furnace were burned over 50% of the body, one died 12 days later.
62-7	3-29-62	CH-Argonne National Laboratory (M. J. Holloran, Inc.).	1 killed		Pipefitter fell 25 feet.
62-10	3-23-62	OR-W. L. Hailey & Co., Inc.	1 killed		Pipefitter crushed by slide of shale from side of trench.
62-11	4- 7-61	HA-General Electric Co.	3 overex-		Criticality incident with plutonium solution. Exposures: one 12-30 rems; one 100-125 rems; one 40-65 rems.
[d] 62-15	5-29-62	HA-General Electric Co.	1		Employee received cut on right index finger while cleaning debris under pumps in loadout area. 70,000 disintegrations/minute (d/m) detected in excised tissue. Less than 10% maximum permissible body burden estimated to remain at wound site.

See footnotes at end of table.

TABLE No. 12.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]—Continued
(December 1, 1961—November 30, 1962)

No.	Date	Operations Office [b] and Contractor	Injuries and Overexposures	Loss	Remarks
[d] 62-17	6- 2-62	HA-General Electric Co	1	----------	Pipefitter received puncture wound in left index finger while performing maintenance work in a hood. Initial radiation measurement of 250,000 d/m detected at wound site. Tissue excised. Estimate of 10–20% maximum permissible body burden remained at wound site.
62-18	6-20-62	OR-Union Carbide Nuclear Co., Paducah Plant.	1 killed	----------	While breaking a bridge formation of coal in a reclaim hopper, coal gave way, covering two employees. One suffocated.
62-23	7-24-62	OR-Puerto Rico Nuclear Center.	7 overexposed.	0	A crane operator thought he had been given all clear signal and moved rack of irradiated fuel elements into position against aluminum window, which separates exposure room from reactor pool. Exposures received were 80 rem, 55 rem, 20 rem, 15 rem, 7 rem, 3 rem, and 2-3 rem. All were hospitalized on July 25 for observation.
62-24	7-26-62	AL-Monsanto Chemical Co.	5 contaminated.	$4,243	Opening of calorimeter can accidentally discharged alpha contamination into the room atmosphere, causing surface and personnel contamination. Cost was due to decontamination.
62-27	8-14-62	Government (vicinity of Pittsburgh, Pa.).	1	15,000	Train was rammed from the rear by another freight train. Courier hurt but returned to work within 2 weeks. Damage was to Government railway car and contents.
62-28	8-15-62	OR-Union Carbide Nuclear Co.	1 killed	0	Result of burns received when a flash fire occurred during inspection of a manhole port in the side of oil circuit breaker tank in switchyard.
62-29	10- 7-62	NV-Reynolds Electrical and Engineering Co.	1 killed	0	Power wagon overturned.
62-32	8-24-62	ID-Phillips Petroleum Co. HA-General Electric Co.	0	1,600	Trailer and load (a radioactive materials shipping cask) were contaminated 5 rem/hour, due to iodine 131 leaking from the cask. Cost due to cleanup.
[d] 62-33	10 -7-62	NY-Martin Co----------	0----------	5,000	Nuclear electric power plant, McMurdo Sound, Antarctica, damaged by fire.

See footnotes at end of table.

TABLE No. 12.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]—Continued

(December 1, 1961—November 30, 1962)

No.	Date	Operations Office [b] and Contractor	Injuries and Over-exposures	Loss	Remarks
62-34	10-19-62	OR-Union Carbide Nuclear Co.	0	0	Private driver hit truck carrying cylinders of radioactive materials. No damage to truck.
[d] 62-37	11-13-62	ID-Phillips Petroleum Co.	0	0	Slight increase in radioactivity levels caused temporary evacuation.

[a] COVERS:

Loss or Damage to Government Property, $100,000—up.

Injury or Death, (1) Fatal or imminently fatal injury; (2) Five or more injured; (3) Allegations that persons previously employed by AEC or its contractors died from or were injured as a result of their duties in atomic energy operations.

Radiation Exposures, (1) 25 rem or more whole body, 150 rem skin, 375 rem feet, ankles, hands, forearms; (2) Any release of radioactive material off-site which exceeds RPG's; (3) 25 rem or more external whole body during calendar year; (4) Any unplanned release of radioactive material which exceeds in 24 hours, 5000 X Appendix B, Table II-10 CFR 20.

Public Interest, (1) Any accident or radiation exposure which gives rise to an inquiry by members of the public; or an inquiry from the press; or which the field office manager believes to have pubic information significance; (2) Any off-site accident involving vehicles carrying AEC shipments of radioactive materials.

Miscellaneous, (1) Any accident in which an atomic or nuclear weapon (under the jurisdiction of AEC) is involved and where damage is inflicted to persons or private property; (2) Any injury or industrial illness following cumulative or massive exposure to internal or external ionizing radiation which might reasonably be expected to have caused the illness or injury and when so diagnosed by a physician competent in nuclear medicine; (3) Allegations that persons previously employed by AEC or its contractors are disabled from injuries or diseases incurred as a result of radiation or exposure to toxic materials which are peculair in kind or degree to atomic energy operations.

[b] Field office abbreviations used in this table:

AL—Albuquerque
BH—Brookhaven
CH—Chicago
HA—Hanford
ID—Idaho
NV—Nevada
NY—New York
OR—Oak Ridge
SR—Savannah River

[c] Reported under former criteria, see p. 315, "Annual Report to Congress for 1961."

[d] Type "A" only because of press release.

WORK INJURIES IN AEC OPERATIONS

The rate of disabling work injuries in the Commission's operations decreased 9 percent—from 2.03 per million man-hours worked in 1961 to 1.98 in 1962.

There was a decrease in the number of fatal accidents from 11 in 1961 to 7 as of November 30, 1962.

RADIATION EXPOSURE OF AEC CONTRACTOR PERSONNEL [31]

Annual surveys among the Commission's contractor employees show that of the more than 95,000 monitored in 1961, 99.9 percent received less than 5 rems within the year, 94.5 percent received only 1 rem or less. The following table gives details for the year 1961 (latest data available):

EXPOSURE OF AEC CONTRACTOR PERSONNEL TO PENETRATING RADIATION

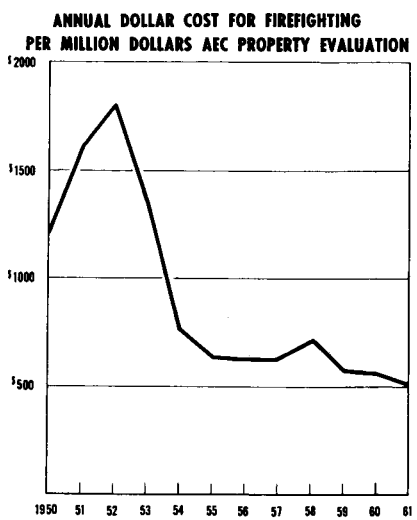
Range of Annual Total Exposure in REMS [a]	*No. of workers*	*Percent Number of Workers*
0–1	90,651	94.55
1–5	5,174	5.4
5–10	40	.04
10–15	2	.002
Above 15	[b] 8	.008
TOTAL	95,875	

[a] The rem is a measure of the dose of ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of 1 roentgen of high voltage X-rays.

[b] Resulted from emergency activities in the accident involving the SL–1 Reactor at ID on January 3, 1961.

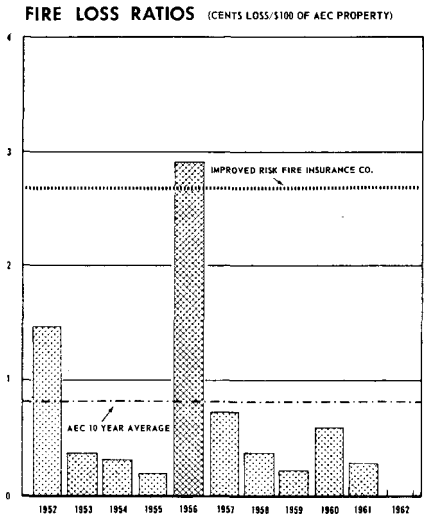
AEC PROPERTY DAMAGE AND LOSS EXPERIENCE

In each year of AEC history, 90 percent or more of the aggregate reported property damage from fire, explosion, wind, and other accidental causes has resulted from those relatively few incidents which involved individual losses of over $50,000. A breakdown of such large loss incidents is shown in the chart.



[31] Radiation exposures among employees of Commission licensees are reported under the "Compliance" section of Part Four.

Except for 1961, fire has been the principal cause of AEC accidental property damage and loss during every year of AEC history. During 1961, AEC fire losses amounted to 0.273¢ per $100 of AEC-owned property compared (on the same basis) to the 0.8¢ 10-year AEC average experience and the private industrial average of about 2.8¢. AEC fire loss statistics include all known direct damage resulting from fire (*eg.*, heat, smoke, water, fire-spread contamination, etc.), but exclude costs resulting from loss of use or occupancy. Recurring firefighting costs on AEC facilities are shown on the charts. The comparable average annual costs of private improved risk industry have been reported [32] to be equivalent to 24.7 cents per $100.00 of property evaluation.



New Film

"Radiation in Perspective" is a new 45-minute color lecture-demonstration film which relates the radiation hazard to other hazards of life in a manner which has been found very successful in the Commission's operational safety program and other programs for public safety officials, transportation executives, educators and other community leaders. Wide public distribution is planned. (See Films Section under Information Programs, Part Four.)

RADIOLOGICAL ASSISTANCE PROGRAM

During the first 9 months of 1962, the AEC radiological assistance organization responded to 45 requests for emergency assistance in in-

[32] Source: Master's Degree thesis report of Carrol E. Burtner titled "The Determination of a Quantitative Method of Evaluating the Fire Protection Program of the Bureau of Yards and Docks," dated June 1961, George Washington University, Washington, D.C.

cidents involving radioactive materials. In addition to these, 11 responses were made to incidents that were found not to involve radioactive material. The following table shows the total number of requests received and the disposition made of them.

SUMMARY OF AEC RADIOLOGICAL ASSISTANCE RESPONSES FOR THE PERIOD

January 1 through September 30, 1962

Region and Office	Total Requests	Disposition of Requests			Radioactivity Involved	
		Team Sent	Man Sent	Advice Only	Yes	No
1. NY	13	1	4	8	7	6
2. OR	8	6	1	1	6	2
3. SR	1	1			1	
4. AL	8		1	7	8	
5. CH	10	3	1	6	9	1
6. ID	1	1			1	
7. SAN	12		6	6	12	
8. HA	3	1	2		1	2
TOTAL	56	13	15	28	45	11

Types of Incidents

A study of 211 incidents to which emergency responses were made during the years 1960 and 1961, and the period January 1 through September 30, 1962, shows that of these incidents about 41 percent involved transportation, 20 percent occurred at a facility, 11 percent occurred off-site but not in transportation, 3 percent were related to alleged fallout, 10 percent were the result of pranks, and 15 percent were referred to others for response. There were no AEC radiological emergency responses to incidents involving nuclear weapons.

Special Training

Through the cooperation of the Defense Atomic Support Agency (DASA) of the Department of Defense, AEC and contractor personnel are able to obtain special training in the effects of nuclear weapons accidents and emergency operations to cope with weapons accidents. During Fiscal Year 1962, more than 140 AEC and contractor personnel attended a DOD Atomic Weapons Safety Indoctrination Course which was presented for military personnel at 14 U.S. Army installations. Since 1958, more than 70 AEC and contractor medical personnel, and other individuals with key positions in AEC radiological

assistance team activities, have attended the semiannual Armed Forces Medical Symposium conducted by DASA at Sandia Base, N. Mex. This symposium is held principally for medical officers in the military service.

Since the first training session in 1957, more than 300 AEC emergency team personnel have attended special radiological emergency team training courses for AEC and contractor personnel at the Nevada Test Site.

Interagency Plan

The Department of Agriculture is now signatory to the Interagency Radiological Assistance Plan (IRAP).[33] This brings the number of signatory Federal agencies to a total of 12. The Office of Civil Defense (OCD), Department of Defense, is continuing the radiological assistance participation originally carried on by the Office of Civil and Defense Mobilization (OCDM), which was abolished during 1961.

INSPECTION AND APPRAISAL

A detailed inventory of the appraisal practices followed by the AEC Headquarters' program divisions, in their evaluation of the technical performance of contractors, has been largely completed. Information and experience was exchanged with the Department of Defense and NASA on techniques for evaluation of the performance of contractors engaged in advanced systems development. The results of this exchange and of the inventory are being used in AEC's continuing effort to develop an improved capability for evaluating its contractors' performance.

The appraisal programs for 1963 which have been prepared by the Commission staff reflect plans to follow a more selective procedure in applying appraisals in those programs and areas of activity most in need of evaluation. This reorientation of the Commission's management appraisal program has been in progress since last year.

An evaluation of the overall performance of AEC Field Offices was prepared and presented to agency management on the basis of appraisal data supplied by Headquarters offices which have program interests at the Field Offices. Increased use of performance information was made by the Field Offices in determining contract actions regarding their major cost reimbursable contractors.

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[33] See pp. 322–323, Annual Report to Congress for 1961.

Special reactor safety inspections and other studies were conducted to gather data for the appraisal of the effectiveness with which the Headquarters staff and the Managers of Field Offices are carrying out assigned reactor safety responsibilities. Such studies and reports indicate that significant improvements in the safety program for AEC-owned reactors have taken place in the last 2 years.

A review was made of AEC compliance procedures and administration, with emphasis on the effectiveness of followup and enforcement actions stemming from safety violations by licensees. Improvements in the procedures have been made.

As in previous years, investigations and reviews were made of incidents involving such matters as health and safety, employee conduct, and possible violations of law in Commission, contractor and licensee operations.

NUCLEAR MATERIALS MANAGEMENT

Review of Nuclear Materials Management System

In 1961, the Commission signed a contract with the Stanford Research Institute, Menlo Park, Calif., to study and evaluate the Commission's nuclear materials management system. The purpose of this review was to assure the public, the Congress, and the Commission that proper administration was being maintained over source and special nuclear materials and to determine that the existing system of control was suitable to present conditions. In addition, the review was to provide assurance, or recommend corrective measures to assure, that the system would detect significant diversions of source and special nuclear materials, and that the system is sufficiently flexible to permit development of peaceful applications of atomic energy.

The Stanford Research Institute study, which was completed in 1962, concluded that the AEC is meeting the requirements of the Atomic Energy Act of 1954, as amended, in its administration of SS materials. Some suggestions were made for the use of advanced and modified management techniques and for some changes that would improve the system capability for detection of diversion of special nuclear materials.

Selected Measurement Methods

Preparations for publication of measurement methods for use in atomic energy operations continued during the past year and approximately 50 methods have been selected for publication. The program was started in 1960 to select suitable methods for measuring the prop-

erties and quantities of source and special nuclear materials transferred between the Commission and private industry. Publication of these methods under the title "Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle" is expected by mid-1963.

The activities of this program in evaluating and selecting measurement methods have been coordinated with the American Society for Testing Materials and the American Standards Association to prevent duplication of effort and to assure compatible results.

Standard Reference Materials

Samples of high purity plutonium metal prepared and analyzed by the Los Alamos Scientific Laboratory in cooperation with the National Bureau of Standards (NBS) became available from NBS in April 1962, as certified plutonium chemical standards.

Work has continued on better characterization of the 15 uranium isotopic standards now available from NBS. Studies have continued to establish a primary uranium standard to provide an absolute basis for values on all uranium standards either chemical or isotopic.

The programs for preparation and certification of a uranium 236 isotopic standard and of plutonium isotopic standards were continued. These programs included arrangements to obtain small quantities of the pure uranium 236 and plutonium isotopes for use by the National Bureau of Standards as primary certification standards.

Ad Hoc Review of Cold Scrap Reprocessors

The Commission's Division of Nuclear Materials Management established an Ad Hoc Task Force in November 1961 to review the large differences in uranium content of cold scrap as estimated or measured by the fuel fabricator and as subsequently analyzed by the reprocessor after dissolution, and to recommend technical and/or administrative changes to reduce the probability of future significant shipper-receiver differences. The Task Force concluded that one significant contribution to the large differences was lack of adequate measurement data on the part of some of the fuel fabricators. Steps are being taken to evaluate and improve measurement procedures.

Meetings

The annual meeting of Commission and contractor personnel was held in Chicago, Ill., October 3–5, to discuss matters of mutual concern in the nuclear materials management field. This was the eighth annual meeting of this type.

MOBILIZATION PLANNING

Active participation was continued in planning for mobilization and continuity of Government programs designed to develop a state of readiness with respect to all conditions of a national emergency, including attack on the United States. This planning was in coordination with the Office of Emergency Planning (OEP) and the Office of Civil Defense (OCD) in the Department of Defense (DOD). The Commission was represented on the eight Regional Civil and Defense Mobilization Boards, and furnished advice and support to OEP and OCD as needed.

Emphasis continued to be given in Commission planning to the protection of the post-disaster health and safety of the public by planning to shut down, in anticipation of an imminent enemy attack, all AEC facilities which could otherwise constitute a significant hazard. Such facilities would also be kept under surveillance.

Active participation was continued in the Defense Materials and Priorities System under the Defense Production Act of 1950, as amended, as well as other industrial mobilization and mobilization readiness programs under the act.

Within the framework of an OCD program, the Commission undertook to train AEC and contractor engineers to identify existing fallout shelters for use in an emergency. A program of such identification was begun in all offices. The Commission's Los Alamos Office, in cooperation with the community and OCD, successfully completed an operation in which adequate shelter space for the entire population of Los Alamos, N. Mex., was identified, marked, and stocked.

The Commission carried out a comprehensive program of tests under an OEP exercise entitled "Spade Fork," similar to previous Operations Alert but over a more extended period of time. This included considerable interplay with DOD elements at all levels. Commission relocation centers were activated and long-standing readiness plans were invoked. Post-attack emergency plans were tested following the simulated nuclear attack upon this country. The Commission also participated in the resource management phase of the exercise.

Shortly after the ending of exercise Spade Fork in October, a period of actual increased international tension required operational use of AEC emergency plans. Experience gained in Spade Fork contributed materially to the speed and completeness of AEC reactions to the actual situation requiring an increased state of readiness.

ORGANIZATION AND PERSONNEL

Organizational Changes

Major organizational changes within the Atomic Energy Commission during the January–December 1962, reporting period were:

Nevada Operations Office

Effective March 6, 1962, the Nevada Operations Office was established at Las Vegas. It reports directly to the General Manager. Superseding the Office of Field Operations in the Albuquerque Operations Office, the Nevada Operations Office is responsible for:

1. Managing the Nevada Test Site (NTS) and other experimental nuclear explosive test sites outside of the NTS.
2. Providing site supporting services to the various users of NTS, as overall site manager, concentrating on site-wide problems associated with construction, labor relations, transportation, housing, and other arrangements requiring increasing attention for the weapons, nuclear explosives, and reactor programs.
3. Contract negotiation and administration, legal, information, construction, fiscal, personnel, labor relations, security, safety, and other administrative services.

Division of Nuclear Education and Training

A new Division of Nuclear Education and Training, reporting to the Assistant General Manager for Research and Development, was established on March 1, 1962, and fully activated on July 2, 1962. The following nuclear education and training programs have been integrated to form the new division:

1. Programs in the engineering and physical sciences, including equipment grants, loans of nuclear materials, faculty training, fellowships and course development, previously administered by the Coordinator, Nuclear Education and Training in the Office of the Assistant General Manager for Research and Development.
2. Similar programs in the engineering and physical sciences, including faculty training and course development, previously administered by the Division of Isotopes Development.
3. Similar programs in the life sciences, such as radiation biology, health physics, industrial medicine and industrial hygiene, previously administered by the Division of Biology and Medicine.

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Division of Plans and Reports

Effective July 30, 1962, a Division of Plans and Reports was established, reporting to the Assistant General Manager for Plans and Production. The Division was established following a recent study of AEC project control practices, to bring together in one organization the competence in techniques in program and project planning, progress analysis, and reporting. This included the abolishment of the Division of Plans and transfer of certain reports preparation responsibilities from the Office of the Controller and Division of Public Information. A principal function of the new Division is assistance to Headquarters divisions and field offices in selecting, installing and maintaining project control systems directed toward improving, monitoring, and reporting on project execution, with particular emphasis on identifying impending problems. The new division also has the responsibility for preparation of periodic Congressional and public reports.

Organizational Relationship Changes

Effective February 26, 1962, the Managers of the Albuquerque Operations Office and the San Francisco Operations Office began reporting directly to the General Manager regarding administrative and operational matters rather than to the Director, Division of Military Application. All Headquarters divisions deal directly with these Operations Offices on matters of mutual responsibility and concern. In major policy matters and on direct assignments to these Operations Offices, Headquarters divisions act for the General Manager and coordinate such matters within the Headquarters.

The Director, Division of Military Application, continues to provide program direction on weapons research and development to the Los Alamos Scientific Laboratory and the Lawrence Radiation Laboratory. Nonweapons research and development program direction to these laboratories is provided by the Assistant General Manager for Research and Development.

Office abolished. The Lockland (Ohio) Area Office of the Oak Ridge Operations Office was abolished effective June 30, 1962.

Personnel Changes

During the January–December 1962 reporting period, the following major personnel changes took place:

John S. Graham resigned as Commissioner, effective June 30, 1962.

LOREN K. OLSON's appointment as Commissioner expired effective June 30, 1962.

JOHN G. PALFREY, formerly Dean of Columbia University Undergraduate College, was appointed as Commissioner by the President, confirmed by the Senate, and sworn in August 31, 1962, for a term of 5 years expiring June 30, 1967. He replaced former Commissioner Loren K. Olson.

JAMES T. RAMEY, formerly Executive Director, Joint Committee on Atomic Energy, was appointed as Commissioner by the President, confirmed by the Senate, and sworn in August 31, 1962, for the unexpired term of former Commissioner John S. Graham which will end June 30, 1964.

Dr. FRANKLIN A. GIFFORD, Jr., member of the Advisory Committee on Reactor Safeguards since September 1958, was elected Chairman of the Committee, effective January 1, 1962.

Dr. MANSON BENEDICT, member of the General Advisory Committee since October 1958, was elected Chairman of the Committee, effective February 16, 1962.

Dr. RUSSELL S. POOR, formerly Provost, J. Hillis Miller Health Center, University of Florida, was appointed Director, Division of Nuclear Education and Training, effective March 9, 1962. He assumed the duties of the Director on a full-time basis effective June 24, 1962.

JAMES E. REEVES, formerly Assistant Manager for Field Operations, Albuquerque Operations Office, was appointed Manager, Nevada Operations Office, effective March 6, 1962.

DON S. BURROWS, formerly Controller, resigned effective March 18, 1962. He was succeeded by JOHN P. ABBADESSA, formerly Deputy Director, Civil Accounting and Auditing Division, General Accounting Office, effective April 15, 1962.

NEIL D. NAIDEN, formerly General Counsel of the Commission, resigned effective July 19, 1962. He was succeeded by JOSEPH F. HENNESSEY, formerly Associate General Counsel, effective July 20, 1962.

JOHN L. MCGRUDER, Director, Division of Plans, resigned effective August 14, 1962.

WILLIAM H. SLATON, formerly Deputy Assistant General Manager for Operations, was appointed Director, Division of Plans and Reports, effective July 30, 1962.

CARL M. WALSKE, formerly AEC Scientific Representative, London, England, resigned effective August 27, 1962. He was succeeded by SAMUEL G. NORDLINGER, formerly Chief, Reactor Component Development Branch, Division of Reactor Development.

ABRAHAM S. FRIEDMAN, formerly Senior Chemist, Division of Research, was appointed AEC Scientific Representative, Paris, France, effective February 11, 1962.

Part Five

Regulatory Activities

THE REGULATORY PROGRAM

The Director of Regulation administers the Commission's regulatory program, except for the promulgation of regulations and the performance of the quasi-judicial function. The divisions reporting to the Director of Regulation are: the Division of Licensing and Regulation, responsible for administering the program for licensing and regulating the construction and operation of nuclear facilities, and the possession and use of radioactive materials; the Division of Compliance, responsible for inspection of material and nuclear facility licenses for compliance with license provisions and regulations; and the Division of Radiation Protection Standards, responsible for the Commission's work in establishing radiation protection standards and for working with the various States as they assume regulatory jurisdiction over certain types of activities heretofore under the AEC.

The Commission's quasi-judicial function is performed by the Office of the Hearing Examiners, by atomic safety and licensing boards under the authority of the recently adopted P.L. 87–615, and by the five-member Commission, which formally reviews regulatory decisions either on petition for review, or at its own instance, and informally reviews all regulatory decisions.

LICENSING AND REGULATION

Licensing Activities

Facility Licensing

During 1962, permits were issued by the Commission's Division of Licensing and Regulation for the construction of one power reactor, two research reactors, and one critical experiment facility. Provisional operating licenses or authorizations were issued for seven power reactors, seven research reactors and one critical experiment facility. Licenses were also issued for the export of two power reactors—one to Japan and one to Italy, one critical experiment facility to Japan, and two research reactors to Pakistan and one to Scotland. In addition, numerous amendments were issued relating to existing licenses for power, test, and research reactors. Applications were filed for permits or authorizations to construct and operate three power reactors, one test reactor, three research reactors, three critical experiment facilities, and one production facility.

Licensing actions since 1954 brought the total number of facilities licensed or authorized to operate as of December 31, to 11 power

reactors, 3 test reactors, 62 research reactors, and 15 critical experiment facilities. In addition, permits or authorizations were in effect for the construction of 6 power reactors, 18 research reactors and 1 critical experiment facility.

Chemical Processing Plant

On July 26, 1962, Nuclear Fuel Service, Inc., Baltimore, Md., filed an application under Section 104(b) for a construction permit and a license to operate a nuclear fuel chemical processing plant at the Western New York Nuclear Service Center located in Cattaragus County, N.Y. The plant will engage in processing spent fuels primarily from reactors licensed by the Commission and reactors owned by the Commission. In a report dated October 11, 1962, the Advisory Committee on Reactor Safeguards stated that the site selected could be considered as suitable for a plant of the type and capacity proposed.

Power Reactors

Peach Bottom. Following a public hearing in December 1961 and pursuant to the Hearing Examiner's Initial Decision dated February 2, 1962, a permit was issued to *Philadelphia Electric Co.* on February 23 for the construction of a 115 megawatt (thermal) high temperature, gas-cooled nuclear reactor at a site in Peach Bottom Township, York County, Pa.

Dresden. Since October 14, 1960, the *Commonwealth Edison Co.* has been licensed to operate the Dresden Nuclear Reactor at steady state power levels to 630 megawatts (thermal). In March and April of 1962, Commonwealth requested a license amendment to increase the maximum heat flux limits for the various types of fuel in the Dresden reactor and to increase the maximum steady state power level from 630 thermal megawatts to 700 thermal megawatts. A public hearing to consider these requests was held in August, and pursuant to the Hearing Examiner's Initial Decision dated September 4, a license amendment was issued on that date to permit operation of the Dresden reactor under the requested conditions.

Carolinas-Virginia. On November 26, 1962, a provisional operating license was issued to Carolinas-Virginia Nuclear Power Associates, Inc., for the operation of its 17,000 electrical kilowatt vertical pressure tube, heavy water moderated and cooled power reactor at Parr, S.C.

Saxton. As noted in the 1961 Annual Report, *Saxton Nuclear Experimental Corp.* was granted a Provisional Operating License on November 16, 1961, which specified that core loading and operation

of its reactor near Altoona, Pa., could begin after the Commission had found that construction of the reactor had been completed in conformity with the construction permit previously issued. This finding was made on April 3, 1962, at which time Saxton proceeded to load the first core and operate its pressurized water reactor off at thermal power levels to 200 kilowatts. Saxton was further permitted, on August 15, to increase the operating level to 20 megawatts thermal. Saxton also requested a license amendment to conduct Phase I of its Research and Development Program and to extend the term of its provisional operating license. Following a public hearing in July and pursuant to the Hearing Examiner's Initial Decision dated August 31, 1962, the Provisional Operating License was amended as requested on October 9, 1962.

Hallam. Pursuant to the Hearing Examiner's Initial Decision dated December 28, 1961, a Provisional Operating Authorization was issued effective January 2, 1962, authorizing *North American Aviation, Inc.*, to operate the Hallam Nuclear Power Facility for the conduct of the "Dry Zero-Power Experiments" in order to verify physics calculations on the nuclear core. This facility is a sodium graphite reactor with a rated capacity of 75 electrical megawatts. It was built for the Atomic Energy Commission and is to be operated, under the terms of the Provisional Operating Authorization, by North American Aviation, Inc. The land on which the facility is located is owned by Consumers Public Power District of Lincoln, Nebr., who will ultimately operate the reactor. Following a further public hearing in July and pursuant to the Hearing Examiner's Initial Decision dated July 31, and findings by the AEC that construction of the facility and all preoperational tests necessary for the proposed activities had been satisfactorily completed, a Provisional Operating Authorization Amendment was issued on August 9, authorizing North American Aviation, Inc., to operate the facility for the conduct of the "Wet Critical Experiments" and operations not in excess of 15 percent of full power.

Piqua. A Provisional Operating Authorization was issued on August 23 to *North American Aviation, Inc.*, for initial operation of a nuclear power reactor at Piqua, Ohio. Under the authorization, initial core loading and operation of the organic cooled and moderated facility will not begin until the Commission has found that construction of the facility and preoperational tests have been satisfactorily completed. Issuance of the authorization followed a public hearing held in June, and the Hearing Examiner's Initial Decision of June 27. The facility which has a rated capacity of 11.4 electrical megawatts was built for the Atomic Energy Commission by North American

Aviation, Inc. The City of Piqua provided the nuclear plant site and conventional turbine generator and will ultimately operate the entire plant.

Indian Point. Following public hearings and pursuant to the Hearing Examiner's Initial Decision of February 21, 1962, a Provisional Operating License was issued on March 26 to *Consolidated Edison Company of New York, Inc.*, for initial operation of its pressurized water, thorium-uranium nuclear reactor located at Indian Point, N.Y. The license provided for loading of the reactor, conduct of tests, and operation at steady state power levels up to 585 thermal megawatts, but specified that prior to core loading and operation of the reactor the AEC must find that construction of the facility had been completed in conformity with the construction permit previously issued. This finding was made on May 15, 1962, at which time core loading and operation of the reactor up to 585 thermal megawatts was authorized.

Humbolt Bay. Following a public hearing in July and pursuant to the Hearing Examiner's Initial Decision of August 17, a Provisional Operating License was issued to the *Pacific Gas and Electric Co.* on August 28, 1962, for initial operation of its boiling water nuclear reactor located at the company's Humboldt Bay Power Plant near Eureka, Calif. The license provides for loading of the reactor, conduct of tests, and operation of the reactor at steady state power levels up to and including the rated power level of 50 electrical megawatts, but specifies that the core may not be loaded and operation may not begin until the AEC has found that construction of the facility has been completed in conformity with the construction permit previously issued.

Big Rock Point. Following a public hearing in July and pursuant to the Hearing Examiner's Initial Decision of August 16, a Provisional Operating License was issued on August 30, 1962, to *Consumers Power Co. of Michigan* for initial operation of its high power density boiling water nuclear reactor located at Big Rock Point, Mich. The license permits loading of the reactor, conduct of tests, and operation of the reactor at steady state power levels up to its initial rated power of 50 electrical megawatts, but specifies that the core may not be loaded and operation of the reactor may not begin until the AEC has found that construction of the facility has been completed in conformity with the construction permit as previously issued. This finding was made on September 26, 1962. On November 1, 1962, Consumers Power Co. was licensed to proceed to 157 thermal megawatts.

Yankee. On July 29, 1960, *Yankee Atomic Electric Co.* had been granted a license to operate its pressurized light water power reactor, located at Rower, Mass., at steady state power levels up to 392 thermal megawatts. Based on operating experience gained in the ensuing year, Yankee applied for, and received, an amendment to its license on June 23, 1961, for operation at higher power levels up to 485 thermal megawatts. With the expiration of the life of the first core and its replacement with an identical core during 1962, Yankee applied for a further amendment for operation at power levels up to 540 thermal megawatts. Following a public hearing held in September, and pursuant to the Hearing Examiner's Initial Decision dated October 10, 1962, Yankee's license was amended on October 11, 1962, to permit operation of the reactor at steady state power levels up to a maximum of 540 thermal megawatts.

Elk River. Public hearings were held in August and September to consider issuance of a Provisional Operating Authorization for initial operation of the Elk River reactor located at Elk River, Minn. The facility is an indirect cycle, boiling water type reactor designed to provide 58.2 thermal megawatts of energy, and is capable of producing 22 electrical megawatts. The reactor has been constructed for the Atomic Energy Commission and will be operated initially by Allis-Chalmers Manufacturing Co. on a site furnished by the Rural Cooperative Power Association of Elk River (RCPA). On the basis of present information and subject to plans to review the matter as new data become available, it has been determined that the pressure vessel for the reactor can be used only for 250 pressure-temperature cycles (as defined in the license) or for five operating years, whichever occurs sooner.

Pursuant to a Memorandum Opinion and Interim Authorization Order issued by the Presiding Officer on November 5, 1962, the Division of Licensing and Regulation on November 6, 1962, issued a provisional operating authorization. On November 9, 1962, Change No. 1 to the provisional operating authorization was issued authorizing certain revisions in the technical specifications for the period of initial loading and testing at low power. On November 16, 1962, the Presiding Officer issued an Initial Decision reaffirming the findings and conclusions of the Memorandum Opinion and Interim Authorization Order of November 5, 1962, and rescinding its operative provisions. On November 16, 1962, Mr. F. S. Cartwright of Shevlin, Minn., submitted (*1*) a motion to fully recognize him as a party and to correct the proposed Initial Decision accordingly, and (*2*) a recommendation that no license be issued to anyone to operate the Elk River reactor. On December 21, 1962, the Commission issued a Memorandum and Order denying Mr. Cartwright's motion and recommendation.

On December 31, 1962, the Commission adopted the findings of fact and conclusions of law of the Initial Decision dated November 16, 1962, and confirmed the issuance of the provisional operating authorization and the issuance of Change No. 1 thereto. The Commission concluded, however, that a course preferable to that in which a Memorandum Opinion is issued would be the issuance of an initial decision directing issuance of a provisional operating authorization, subject to any conditions prescribed by the initial decision. The Commission further concluded that where significant safety questions have been raised in a proceeding, it would appear desirable by appropriate provisions in the order to permit the Commission a brief period (about 10 days) before the provisional operating authorization becomes effective, to determine whether to review the decision formally and whether any further order should be made on the Commission's own motion.

La Crosse. In November, an application was filed by Allis-Chalmers Manufacturing Co. for authorization to construct the La Crosse Boiling Water Reactor at Genoa Station, Vernon County, Wis. The reactor is a direct cycle, forced circulation, boiling water reactor having a designed capacity of 50,000 kilowatts (electrical). It will be constructed by Allis-Chalmers under the second round Power Demonstration Reactor Program on land owned by Dairyland Power Cooperative of La Crosse, Wis. The Cooperative will ultimately operate the reactor.

Consolidated Edison, Ravenswood Station. Consolidated Edison Co. of New York, Inc., submitted an application dated December 10, 1962, for a construction permit to own and construct in New York City a pressurized water nuclear facility having an electrical capacity of approximately 1,000 megawatts derived from 2,030 thermal megawatts from a nuclear reactor and 820 thermal megawatts from oil-fired superheaters. The first core proposed for the reactor will utilize 103,000 kilograms of uranium oxide. The site proposed for construction of the nuclear facility is an 8.7-acre segment of a 39-acre tract of land owned by the applicant and located on the East River in the Borough of Queens, N.Y., opposite Welfare Island. The earliest estimated date for completion of the facility is October 1, 1969.

Test Reactors

Plum Brook. As reported in 1961, a Provisional Operating License was issued *National Aeronautics and Space Administration* (NASA) on March 14, 1961, for operation of its Plum Brook Test Reactor at Sandusky, Ohio. Pursuant to the terms of its license and based on findings made by the Commission, NASA on June 12, 1961, was permitted to load and operate the reactor at thermal power level of 1

kilowatt and on May 1, 1962, at power levels to 100 kilowatts (thermal). Following public hearings held in May and June and pursuant to the Hearing Examiner's Initial Decision of August 13, a license amendment was issued August 23 for operation of the Plum Brook Reactor at full rated power of 60 megawatts (thermal), and for the conduct of a limited experimental program in the reactor. The license amendment specified that operation above 100 thermal kilowatts may not begin until the AEC has found that construction of the facility has been completed in conformity with the construction permit previously issued and the application for amended license.

National Bureau of Standards. The National Bureau of Standards had, during 1961, filed an application for license to construct and operate a 10 megawatt (thermal) heavy water moderated and cooled reactor near Gaithersburg, Md. On November 28, 1961, a public hearing was held to consider the issuance of a construction permit. An Intermediate Decision by the presiding officer was issued on January 26, 1962, which deferred decision in the matter pending the development of additional data on certain aspects of design and until NBS selected a contractor for construction of the facility.

Waltz Mill. The *Westinghouse Electric Corp.* advised the Commission that it had ceased operation of the Westinghouse Testing Reactor located at Waltz Mill, Pa., as of March 22, 1962, and subsequently requested a license amendment to cover a two-phase program for shutdown and permanent retirement of the reactor. Westinghouse was advised by letter of August 17 that the first phase of the shutdown program involving primarily the removal of fuel and decontamination and/or restriction of access to the facility could be conducted under the provisions of its existing license and that amendment of the license for possession only would be considered on completion of the shutdown.

The Babcock & Wilcox Co. On December 10, 1962, a hearing was held in Lynchburg, Va., to consider issuance to the Babcock and Wilcox Co. of a provisional construction permit for a test reactor designed to operate initially at 6 Mw(th) with one loop. An Atomic Safety and Licensing Board was appointed and was the first to conduct such a proceeding. The Board consisted of Mr. Arthur W. Murphy, chairman, and members Dr. Patrick W. Howe and Dr. R. L. Doan. On December 21, 1962, the Commission ordered that, in the discretion of the Atomic Safety and Licensing Board, any initial decision directing the issuance of a provisional construction permit in the proceeding might provide that the initial decision be effective immediately on issuance subject to the Commission's Rules of Practice.

Power Reactor Development Co. A Notice of Hearing was issued on November 9, 1962, ordering this matter to be heard before an Atomic Safety and Licensing Board on December 11, 1962, to consider whether a provisional license for operations not in excess of one megawatt should be issued. The Fermi Reactor Facility is a sodium cooled, fast breeder reactor designed for ultimate operation at approximately sixty electrical megawatts. It has been constructed by Power Reactor Development Co. at a site on Lake Erie between Detroit, Mich., and Toledo, Ohio. A prehearing conference was held on November 26, 1962, at which time the case was continued until January 3, 1963. On December 21, 1962, a motion was filed by ". . . intervenors UAW, IUE, and the Paper Makers . . ." requesting a postponement of the hearing. On December 28, 1962, the Atomic Safety and Licensing Board appointed for the proceeding denied the motion.

Operator Licenses

In the year ending November 30, 1962, 548 reactor operator licenses, including amendments, were issued. These included 295 new licenses and 253 license amendments and renewals. As of November 30, there were 852 operator licenses in effect.

Special Nuclear Material Licenses [1]

For the year ending November 30, 1962, there were 424 licensing actions involving the possession and use of special nuclear material. These included 112 new licenses and 312 license amendments, renewals, and authorizations. As of November 30, there were 454 AEC special nuclear material licenses in effect.

UF_6 conversion. Five companies continued, under license, to engage in the conversion of uranium hexafluoride (UF_6) obtained from AEC plants to the forms needed for fabrication of fuel elements for use as reactor fuel and for research and development. They were the Davison Chemical Co., Erwin, Tenn.; United Nuclear Corp., Chemicals Div., Hematite, Mo.; Nuclear Materials and Equipment Corp., Apollo, Pa.; Spencer Chemical Co.,[2] Kansas City, Mo., and General Electric Co., San Jose, Calif.

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[1] As indicated elsewhere in this report, four States have entered into agreements with the Commission for the transfer of certain of the Commission's regulatory authority for the control of byproduct material, source material, and special nuclear material in quantities not sufficient to form a critical mass. Accordingly, the licensing statistics provided herein with respect to such materials relate only to licensing activity by the AEC.

Fuel fabrication. As of November 30, there were 16 concerns licensed to fabricate fuel elements in their own facilities, for sale, for their own use, or for research purposes. This is in addition to work performed under Commission contract which does not require a license. Three firms, Clevite Corp., Cleveland, Ohio, Englehard Industries, D. E. Makepeace Div., Plainville, Mass., and Lockheed Aircraft Corp., Marietta, Ga., previously licensed for the fabrication of fuel elements, withdrew from this activity during the year. The licensed fabricators are:

Aerojet-General Nucleonics, San Ramon, Calif.
The Babcock & Wilcox Co., Lynchburg, Va.
Battelle Memorial Institute, Columbus, Ohio
Carborundum Co., Niagara Falls, N.Y.
Combustion Engineering, Inc., Windsor, Conn.
Davison Chemical Co., Erwin, Tenn.
General Dynamics Corp., General Atomic Div., San Diego, Calif.
General Electric Co., Atomic Power Equipment Dept., San Jose, Calif.
Metals & Controls, Inc., Attleboro, Mass.
Martin-Marietta Corp., Middle River, Md.
National Lead Co., Albany, N.Y.
Nuclear Materials and Equipment Corp., Apollo, Pa.
Nuclear Metals, Inc., Concord, Mass.
Sylvania Electric Products, Inc., Hicksville, N.Y.
United Nuclear Corp., Fuels Div., New Haven, Conn.
Westinghouse Electric Corp., Forest Hills and Cheswick, Pa.

Uranium reclamation. The following licensed companies reclaim unirradiated enriched uranium from scrap generated in fuel fabrication and fuel material preparation:

Davison Chemical Co., Erwin, Tenn.
Nuclear Materials and Equipment Corp., Apollo, Pa.
Spencer Chemical Co., Kansas City, Mo.[2]
United Nuclear Corp., Chemicals Div., Hematite, Mo.

Englehard Industries, Inc., Baker Platinum Div., Newark, N.J., previously licensed for a uranium scrap refining operation, withdrew from this activity during 1962.

Source Material Licenses

Licenses issued for the year ending November 30 which authorize possession and use of source materials totaled 289. This figure includes 127 licenses issued to exporters. As of November 30, there were 460 AEC source material licenses in effect, exclusive of export licenses.

[2] The nuclear operations of Spencer Chemical Co. were taken over by Kerr-McGee Oil Industries, Inc., during the year.

Byproduct Material Licensing (Radioisotopes)

During the year ending November 30, 1,500 byproduct material licenses and 6,025 amendments of existing licenses were issued. Included in this number are 1,087 new byproduct material licensees: 304 in the field of medicine, 354 industrial firms, 374 Federal and State laboratories, and 55 in other fields. As of November 30, 5,874 organizations and individuals in the United States possessed AEC byproduct material licenses. Appendix 9 shows the number of byproduct material licensees by State and type of user. Nine licenses were issued, pursuant to Section 30.24(f) of Part 30, Code of Federal Regulations, to authorize distribution of various types of gaging, ion generating, and chromatographic analytical devices for use under general license. As of November 30, there were 24 licenses in effect for this activity.

In September, 1962, the Atomic Energy Commission issued a license to Nuclear Engineering Co., Pleasanton, Calif., for disposal of radioactive wastes by land burial at a site near Beatty, Nev. This is the first license for a comercial land burial facility. The site is owned by the State of Nevada and leased to Nuclear Engineering Company.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

During 1962, the Advisory Committee on Reactor Safeguards (ACRS) held 11 meetings of the full committee and 22 subcommittee meetings. It furnished to the Commission 35 letters of advice concerning 11 privately owned, 10 Commission-owned, and 5 reactor projects owned by other agencies of the Federal Government. (More complete details on ACRS activities will be carried in the Commission's Annual Report on Indemnification and ACRS Operations which will be submitted in April 1963.)

Dr. Herbert J. C. Kouts of Brookhaven National Laboratory was appointed to the Committee by the Commission. The ACRS elected Dr. D. B. Hall to serve as its chairman, and Dr. C. R. Williams to serve as vice-chairman during calendar year 1963.

A complete listing of the Committee members is given in Appendix 2.

ATOMIC SAFETY AND LICENSING BOARDS

Important amendments to the Atomic Energy Act, relating to regulatory proceedings, were enacted in August 1962. The amendments, which permit greater flexibility and informality in the conduct of licensing proceedings, authorize the Commission to establish one or more atomic safety and licensing boards; require a mandatory public hearing only at the construction permit phase of a reactor licensing

proceeding; and permit the Commission to use its discretion in referring applications for amendments of reactor construction permits and for operating licenses to the Advisory Committee on Reactor Safeguards.

Three-man Boards

The three-member boards will conduct those public hearings which are assigned to them by the Commission in proceedings involving the granting, suspending, revoking or amending of licenses or authorizations. The Commission is also authorized to delegate to such boards other regulatory functions which the Commission deems appropriate.

Members of the atomic safety and licensing boards will be selected for each case from a panel of experts appointed for that purpose.

Panel Members

The first cases for which the Commission has thus far established boards are those involving the application of Babcock and Wilcox Co. for a permit to construct a test reactor near Lynchburg, Va., and the application of Power Reactor Development Co. for a license to operate the Fermi power reactor at Monroe, Mich., and the application of Allis Chalmers Manufacturing Co. for an authorization to construct the LaCrosse power reactor at Genoa Station, Wis.

As of December 31, 1962, the panel from which the boards will be drawn included J. D. Bond, a hearing examiner for the Commission; Dr. R. L. Doan, manager of the Atomic Energy Division, Phillips Petroleum Co.; Patrick W. Howe, Head of the health chemical department, Lawrence Radiation Laboratory, University of California; Samuel W. Jensch, chief hearing examiner for the Commission; E. Riggs McConnell, a hearing examiner for the Commission; Arthur W. Murphy, a member of the law firm of Baer, Marks, Friedman and Berliner, New York City; Warren E. Nyer, manager of the reactor projects branch, Atomic Energy Division, Phillips Petroleum Co.; Thomas H. Pigford, professor of nuclear engineering and head of the Department of Nuclear Engineering, University of California, Berkeley; Dixon Callihan, Oak Ridge National Laboratory; R. M. Evans, Albuquerque, N. Mex.; Eugene Greuling, Professor of Physics, Duke University; Albert J. Kirschbaum, Lawrence Radiation Laboratory; Hugh Paxton, Los Alamos Scientific Laboratory; Lawrence R. Quarles, Dean, School of Engineering and Applied Science, University of Virginia; and Abel Wolman, Head, Department of Sanitary Engineering and Water Resources, Johns Hopkins University.

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RULES AND REGULATIONS

During the year, the Commission adopted three new regulations and a new section of an old regulation, amended eight regulations, and revised one. Proposed amendments for eight regulations were also published in the *Federal Register* for public comment.

Regulations and Amendments Put Into Effect

Part 1, "Statement of Organization, Delegations and General Information," Part 20, "Standards for Protection Against Radiation," and Part 31, "Radiation Safety Requirements for Radiographic Operations

On June 22, 1962, amendments were published to reflect recent changes in the organization of the Division of Compliance, establishing five Regional Compliance Offices. These Regional Compliance Offices now are located at New York City; Chicago, Ill.; Atlanta, Ga.; Denver, Colo.; and Berkeley, Calif., and report directly to the Director of the Division of Compliance at AEC Headquarters.

Part 2, "Rules of Practice"

On January 13, 1962, a major revision of 10 CFR Part 2 was published as an effective regulation. The revision was designed to expedite proceedings and embody the results of experience gained under existing rules, while taking into account the rules of practice of other regulatory agencies and the Federal Rules of Civil Procedure. The revision incorporated into Part 2 the substance of the former Part 3, "Rules of Procedure in Contract Appeals."

On November 7, 1962, Section 2.201 of Part 2 was amended to relieve licensees from certain burdensome and generally unnecessary requirements in the filing of answers to notices of violation sent by the Commission. In the case of minor technical violations, which constitute the great majority of instances in which a notice of violation is sent, provisions such as a direction that the licensee admit or deny the violation and state the reasons for the violation are considered unnecessary. Such violations are usually corrected promptly by the licensee and further proceedings are not required.

Part 2, "Rules of Practice",
Part 50, "Licensing of Production and Utilization Facilities" and
Part 115, "Procedures for the Review of Certain Nuclear Reactors Exempt from Licensing Requirements"
Part 20, "Standards for Protection Against Radiation"

The definition of "source material" in 10 CFR Part 20 was amended on June 22, 1962, to bring it into conformity with the definition of "source material" in 10 CFR Part 40.

Part 30, "Licensing of Byproduct Material"

On February 14, 1962, an amendment to Section 30.21(c) of Part 30 extended the general licenses contained therein to devices manufactured under specific licenses issued by States which have entered into agreement with the Commission pursuant to Section 274 of the Atomic Energy Act and Part 150, "Exemption and Continued Regulatory Authority in Agreement States Under Section 274". This is related to the provision of Part 150 which grants a general license to any person who holds a specific license from an agreement state to conduct the same activity in a nonagreement state.

On March 14, 1962, an amendment to Section 30.21 of Part 30 established a general license for the use in aircraft of luminous buttons or exit markers containing a maximum of 4 curies of tritium, when the device meets the manufacturing specifications of Section 30.24(j).

On March 31, 1962, a new Section 30.24(m), of Part 30 established criteria for issuance of specific licenses for manufacturing or importing lock illuminators which contain tritium and are to be used in automobile locks.

On December 12, 1962, an amendment to 10 CFR Part 30 was published which established a general license for export of certain quantities and forms of tritium and polonium 210. The amendment permits the export of 5,000 curies of tritium and 5,000 curies of polonium 210 in specified form by any person in any one calendar quarter. The general license does not apply to certain countries listed in the regulation. Under this general license, exports by any one licensee are limited to 1,000 curies of tritium to any one country or destination in a calendar quarter and 100 curies of tritium in a single shipment. The report to the Commission of byproduct material exports, now required within 90 days of export, is eliminated as no longer necessary.

Part 30, "Licensing of Byproduct Material" and Part 40, "Licensing of Source Material"

On August 16, 1962, amendments were published to Parts 30 and 40 which prohibit the export of source material or byproduct material from the United States when the exporter knows, or has reason to believe, that any part of the material will be re-exported from the country of ultimate destination as specified in the export documents, unless the Commission has authorized the re-export, or unless the new

country of ultimate destination is one to which the material might be exported from the United States under one of the general licenses established in Sections 30.33 or 40.23 of the Commission's regulations. The amendments parallel the Department of Commerce regulations in these respects.

On December 29, 1962, an amendment to Part 40 was published which broadened the exemption of Section 40.13(c)(5) to include uranium counterweights used in rockets, projectiles and missiles as well as in aircraft. The amendment also defined with greater particularity the type of specific license under which counterweights distributed on a license-exempt basis must be manufactured.

Part 50, "Licensing of Production and Utilization Facilities"

On June 9, 1962, an amendment was published which changed Section 50.36 and added Section 50.59 and Appendix *A* to clarify the extent to which licensees may make changes, and conduct tests and experiments which are not specifically provided for in their facility licenses. Basically, the amendment provides that certain design and operating limitations will be designated as technical specifications which must be adhered to in the absence of specific authorization from the Commission. Changes in the facility and procedures described in the hazards summary report may be made and tests or experiments may be conducted without prior specific Commission authorization if such activities do not involve a change in the technical specifications or an unreviewed safety question. Subsequently it was noted that Section 50.59 inadvertently also applied to construction permittees and, therefore, a corrective amendment was published on September 5, 1962.

On December 29, 1962, an amendment to Section 50.35 was published which clarified the Commission's requirements for issuance of provisional construction permits by identifying more explicitly the principal elements of the safety determination which the Commission makes when it issues a provisional construction permit.

Part 100, "Reactor Site Criteria"

On April 12, 1962, the Commission published general criteria which it will utilize as guides in its evaluation of the suitability of proposed sites for power and test reactors subject to Part 50 and Part 115.

Part 112, Dominic Nuclear Test Series, 1962

On April 26, 1962, a new regulation was published which established danger areas encompassing Christmas and Johnston Islands in connection with the 1962 nuclear test series in the Pacific. The

Christmas Island zone was disestablished on July 12, 1962. The Johnston Island zone was suspended during the period July 31 through September 21. While it was in effect the dimensions of the Johnston Island zone were adjusted at various times to ensure the public health and safety during the high-altitude detonations. Effective November 4, 1962, the Johnston Island zone was disestablished and Part 112 was revoked.

Part 115, "Procedures for the Review of Certain Nuclear Reactors Exempt from Lisensing Requirements"

On March 22, 1962, a corrective amendment of Section 115.45 was published, eliminating the requirement that there be a finding that an applicant in a proceeding under 10 CFR Part 115, relating to certain Commission-owned reactors, be "financially qualified" to engage in the activity to be authorized.

Part 140, "Financial Protection Requirements and Indemnity Agreements"

On March 29, 1962, an amendment to Sections 140.72 and 140.52 was published which establishes the forms of indemnity agreements to be executed by the Commission with Federal agencies and with educational institutions, and eliminates coverage for on-site property for indemnified licensees.

Part 150, "Exemptions and Continued Regulatory Authority in Agreement States Under Section 274"

On February 14, 1962, a new regulation, Part 150, was published which specified certain exemptions [3] from the AEC's regulations for activities within those States with which the Commission has entered into agreements relinquishing regulatory responsibility pursuant to Section 274 of the Atomic Energy Act.

Proposed Regulations and Amendments

Part 9, "Public Records"

On January 26, 1962, a proposed amendment to Part 9 was published in the *Federal Register* for public comment. The amendment, which was a modification of that proposed on October 5, 1961,[4] provided for inclusion in the public record of notices of violation issued by the

[3] See pp. 353–354, "Annual Report to Congress for 1961."
[4] See p. 351, "Annual Report to Congress for 1961."

Commission as well as reports by licensees or holders of authorizations under Part 115, and correspondence between the Commission and licensees or holders of authorizations concerning alleged violations.

Part 20, "Standards for Protection Against Radiation"

On October 17, 1962, proposed amendments to Section 20.203(f) were published which would modify the labeling requirements for containers of licensed byproduct, source and special nuclear materials by including some additional labeling requirements and modifying or dispensing with certain existing ones.

Part 30, "Licensing of Byproduct Material"

On January 18, 1962, a proposed amendment was published which would add new Sections 30.11, 30.26, 30.28, 30.24(k), 30.24(l), and 30.32(g). These would exempt physicians from the licensing requirements of Part 30 for relatively small quantities of specified byproduct materials for certain diagnostic purposes. It would also establish general licenses for larger quantities of these byproduct materials in specified forms for certain therapeutic and diagnostic uses.

On December 8, 1962, proposed amendments of Parts 2, 50, and 115 were published implementing the provisions of Public Law 87-615 which adopted certain amendments to the Atomic Energy Act of 1954 designed to permit greater flexibility and to encourage informality in the conduct of licensing proceedings conducted by the AEC. This law provides for the following: (*a*) establishment of one or more atomic safety and licensing boards to conduct such hearings as the Commission may direct and make such intermediate or final decisions as it may authorize in proceedings with respect to granting, suspending, revoking, or amending licenses or authorizations; (*b*) amends subsection 189a of the Act, which previously required a public hearing prior to granting a construction permit as well as prior to granting an operating license for a power and testing reactor, by limiting the mandatory hearing requirement to the construction permit stage; and (*c*) amends subsection 182b of the Act by clarifying the scope of review by the Advisory Committee on Reactor Safeguards of applications for licenses for power and testing reactors.

Part 110, "Unclassified Activities in Foreign Atomic Energy Programs"

On July 19, 1962, an amendment to Section 110.7 was published which:

1. added Cuba and Poland to the list of countries and destinations excluded from the scope of the general authorization under Section 57(a)(3) of the Act contained in Part 110; and
2. incorporated a further general authorization made by the Commission under Section 57(a)(3)(B) of the Act for the purpose of (*a*) authorizing persons within or under the jurisdiction of the United States to engage in unclassified meetings or conferences sponsored by educational institutions, laboratories, scientific or technical organizations attended by nationals or representatives of any country; (*b*) authorizing participation in unclassified international conferences attended by nationals or representatives of any country; and (*c*) authorizing participation in unclassified exchange programs approved by the Department of State.

Part 110 was also amended by designating the Division of International Affairs rather than the Division of Licensing and Regulation as the addressee in Sections 110.4, 110.8 and 110.10.

OTHER REGULATORY PROCEEDINGS

During 1962, the Commission conducted the following other formal regulatory proceedings:

Industrial Waste Disposal Corp., Houston, Texas

An action entitled *Harris County, Texas* v. *United States of America and Atomic Energy Commission* had been brought in the U.S. Court of Appeals for the Fifth Circuit to review a determination of the Commission granting a waste disposal license to Industrial Waste Disposal Corp., and had been dismissed by the Court of Appeals on June 30, 1961. The proceeding before the Commission had remained open for the purpose of taking evidence as to the integrity of low-level waste containers after disposal at sea. The AEC regulatory staff made a motion before the Commission to deny the application insofar as it requested authority to dispose of wastes in the Gulf of Mexico, without prejudice to a future application if it should appear that such activity would not adversely affect the common defense and security of the United States. By an order of the Commission dated April 20, 1962, the staff's motion was granted and the proceeding was terminated.

Long Island Nuclear Service Corp., Smithtown, N.Y.

A hearing to consider issuance of a license for the storage and transportation of low-level radioactive waste to Long Island Nuclear Service Corp. was held on January 16, 1962, in the Surrogate's Court,

County Center, Riverhead, N.Y. The hearing was held at the request of four interested parties. On March 16, 1962, an Intermediate Decision, which later became the Final Decision of the Commission, granted the requested license.

Southwestern Radiological Service Co., Houston, Texas

A hearing scheduled for January 12, 1962, to be held at Houston, Tex., relative to an "Order to Show Cause" why license should not be revoked was cancelled at the request of Southwestern Radiological Service Co., the licensee. An order of the Hearing Examiner dated January 8, 1962, revoked the license.

Interstate Inspection, Inc., Dallas, Texas

A hearing was scheduled for March 14, at Dallas, Tex., at the request of Interstate Inspection, Inc., relative to an AEC denial of the Company's application for a license to use radioactive materials to perform industrial radiography. The hearing was cancelled following filing of a notice by the Company that it did not then desire a hearing.

Nuclear Advisors, Inc., Long Island City, New York

A hearing was held in New York City on April 6, 1962, in connection with an Order to Show Cause issued to Nuclear Advisors, Inc., Long Island City, N.Y. An Initial Decision issued by the Hearing Examiner on November 2, 1962, found that Nuclear Advisors had violated the Atomic Energy Act, the Commission's regulations and the terms of its license, substantially as alleged in the Order to Show Cause, and ordered suspension of the license for 60 days. On November 23, 1962, Nuclear Advisors filed with the Commission a petition for review of the Initial Decision. On December 12, 1962, the Commission issued an order granting the petition for review but limiting review to the sole issue of whether the Commission's authority to suspend Nuclear Advisors' license was affected by the execution of an agreement between New York and AEC on October 15, 1962, relating to the transfer of certain regulatory authority to New York.

Judicial Review

Proceedings for judicial review of the Commission's decisions were taken in two licensing cases.

City of New Britain, Connecticut v. *United States Atomic Energy Commission and United States of America*

The Commission, on March 24, 1961, issued an amendment of a waste disposal license authorizing the Walker Trucking Co. to receive and store low-level wastes at New Britain, Conn. The City of New Britain, on August 7, 1961, sought judicial review in the U.S. Court of Appeals for the District of Columbia. The principal alleged grounds of the appeal were that the resumption of nuclear testing by the Soviet Union had altered the level of radioactivity in the atmosphere and that the Court should remand the case to the Commission for additional hearings; that the Commission had exceeded its lawful authority in granting the license; and that it had committed certain procedural errors. During the pendency of the appeal, the City made two motions to remand the proceeding to the Commission for the taking of additional testimony. The motions were opposed, and by orders of the court dated January 19, 1962, and May 31, 1962, respectively, decision was held in abeyance of each pending determination of the appeal from the Commission's determination. The appeal was argued on September 12, 1962, and was decided in favor of the Commission on September 27, 1962.

Lawrence W. Goldberg v. *United States of America and Atomic Energy Commission*

In a proceeding on February 2, 1962, the Commission granted Philadelphia Electric Co., a provisional construction permit for a power reactor at Peach Bottom, Pa. Lawrence W. Goldberg—who had made a limited appearance at the Commission hearing—appealed to the U.S. Court of Appeals for the Third Circuit to review the Commission's determination. During the pendency of the appeal, he made a motion for an order staying "all proceedings herein" pending the determination of his petition for review of the Commission's order. The motion was opposed by the Commission and by the applicant, and was denied by the court on May 8, 1962. On motion by the Commission and the applicant to dismiss the appeal on the ground that Goldberg had no standing to prosecute it, the Court dismissed his appeal for lack of jurisdiction on June 5, 1962. A petition to the Supreme Court of the United States for a *writ of certiorari* was filed on September 4, 1962. On November 13, 1962, the petition was denied by the Supreme Court.

OFFICE OF HEARING EXAMINERS

The hearings and proceedings related to both license and contract appeal cases are conducted by the Office of Hearing Examiners. Both

such types of cases have required increased work and time utilized since adoption in 1958 of the hearing procedures, defined in the Administrative Procedure Act, as required by the Atomic Energy Act. The more recent experience, for example, by way of contrast between 1961 and 1962, is that the former year reflects 12 contract cases utilizing 29 hearing days at, or nearby to, the locations of the regional offices of the Commission. In 1962, there were another 12 cases utilizing 33 hearing days.

The licensing proceedings are in two principal categories, initial licensing, primarily for the nuclear power utilization facilities, and the compliance cases. The first category included 11 cases in 1961 absorbing 18 days of hearing; in 1962 the cases actually scheduled totaled 13, with another two more expected before year's end. The time required for these proceedings totaled 25 days through October. The compliance cases are increasing somewhat in the same proportion. Following the hearings in both types of cases, the participants have submitted proposed findings and conclusions, or briefs, from which initial decisions are prepared by the Hearing Examiners for Commission review.

RADIATION INCIDENTS

Radiation incidents occurring in the atomic energy program, both within Commission facilities and under licensee operations, are required to be reported to Commission headquarters. The AEC conducts an investigation into all reported incidents.

LICENSEE REPORTING

During the period October 6, 1961, through November 30, 1962, a total of 35 radiation incidents were reported by licensees, and investigated by the Commission.

Reporting Criteria

Under 10 CFR Part 20, immediate notification to the Commission of any incident is required which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual to 150 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of 1 working week or more of the operation of any facilities affected; or
(4) Damage to property in excess of $100,000.

In regard to those incidents where there can be up to 24 hours delay in reporting, 10 CFR Part 20 states:

"Each licensee shall within 24 hours notify the Director of the appropriate Atomic Energy Commission Regional Compliance Office listed in Appendix D by telephone and telegraph of any incident involving licensed material possessed by him and which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or
(2) The release of radioactive materials in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II; or
(3) A loss of 1 day or more of the operation of any facilities affected; or
(4) Damage to property in excess of $1,000."

RADIATION INCIDENTS REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC

(October 6, 1961–November 30, 1962)

Date of occurrence	Location	Number of persons involved	Extent of exposure	Nature of incident
Oct. 6, 1961	Bakersfield, Calif.			Loss of a 100-millicurie strontium 90 medical applicator. Loss was attributed to poor control of material. The AEC license was terminated upon the request of the licensee.
Oct. 30, 1961	Los Angeles, Calif.	1	5 rem	Exposure occurred when a radiographer was unable to return a 30-curie iridium 192 source to its shielded condition in a device that malfunctioned. The licensee revised its emergency and operating instructions to provide more adequate procedures for individuals to follow in an emergency situation.
Nov. 5, 1961	Burlingame, Calif.	1	8 rem	An employee neglected to return an 8-curie iridium 192 source to its shielded condition in the camera before changing films. No surveys were made to determine whether the source was returned to its storage condition. The licensee instituted steps to assure that such surveys would be conducted in the future.

RADIATION INCIDENTS REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(October 6, 1961–November 30, 1962)

Date of occurrence	Location	Number of persons involved	Extent of exposure	Nature of incident
Nov. 20, 1961	Indianapolis, Ind.	1	4,000–6,000 rad to thyroid.	A radiologist suspected that he had ingested some radioactive material. A subsequent inventory conducted by the hospital indicated that about 2 millicuries of iodine 131 were missing. Some cobalt 60 needles were also found in the chair used by the radiologist. As a result of the AEC investigation it was concluded that the quantity of radioactive material ingested and the radiation dose received by the radiologist were not such as to cause permanent injury. No facts were disclosed requiring enforcement action.
Dec. 20, 1961	San Jose, Calif.	----------	----------	A slurry of depleted uranium leaked out of equipment causing contamination in the laboratory. The incident was the result of a feed line to a dryer becoming plugged and pressure building up in the line. The licensee initiated corrective action by installing new controls on the equipment.
Jan. 2, 1962, Feb. 28, 1962.	Columbus, Ohio	1	88 rem to left hand and 55 rem to right hand.	Exposure received during routine handling of strontium 90 and cesium 13 sealed sources. The licensee took steps to prevent a recurrence of this incident by providing leaded neoprene gloves for such operations.
Jan. 15, 1962	Groton, Conn.	----------	----------	Approximately a month following its receipt by the licensee, a package containing 500 microcuries of carbon 14 could not be found. The material was found three months later in a U.S. Navy ship at sea. Revised procedures were established by the licensee to prevent a recurrence of such a loss.
Jan. 23, 1962	University, Ala.	----------	----------	A leaking 122-millicurie polonium 210 source caused extensive contamination in a physics building and in the homes, automobiles, and personal effects of certain individuals. The licensee has taken steps to improve its procedures in the conduct of leak tests and surveys.
Jan. 26, 1962	Los Angeles, Calif.	----------	----------	A 100-microcurie cobalt 60 source was lost. This was caused when the container in which the source was transported fell from the truck during transit. The lost source was recovered three hours later by local officials.
Mar. 19, 1962	Cambridge, Mass.	----------	----------	A theft of lead bricks slightly contaminated with iron 55, iron 59, and zinc 65 occurred. The persons responsible for the theft were apprehended.
Do	Sante Fe, N. Mex.	----------	----------	Two plutonium 239 sources containing 0.009 and 0.003 microcuries, respectively, were lost while being shipped via mail. The sources were subsequently located by the Post Office Department and shipped to the licensee.

RADIATION INCIDENTS REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(October 6, 1961–November 30, 1962)

Date of occurrence	Location	Number of persons involved	Extent of exposure	Nature of incident
Mar. 21, 1962	Houston, Tex.			Upon returning to his truck, a radiographer noted that survey meter containing a 15-microcurie strontium 90 source was missing. The missing source and instrument was found on a highway and returned to the licensee three days later.
Mar. 23, 1962	West Palm Beach, Fla.			During a routine civil defense training exercise, a 4.5-millicurie OCDM cobalt 60 source was lost. The missing source was found a week later during another training exercise.
Mar. 24, 1962	Norfolk, Va.	2	One person received a dose of 6.5 rem to the hands and 16 rem to the whole body, and a second person received a dose of 4.6 rem to the whole body.	During a test of radiographic equipment containing a 33-curie iridium 192 source, the source was unknowingly left for a while in the exposed position. The licensee took steps to assure that adequate surveys would be made in the future.
Feb. 26, 1962	Columbus, Ohio			An accidental spill of approximately 15 millicuries of strontium 90 as strontium chloride occurred during routine laboratory work. Operations in the laboratory were suspended for about 3 weeks while the affected facility was decontaminated.
Do	Bethesda, Md.			Several cobalt 60 sources in an irradiation facility leaked, causing contamination on surfaces in, and immediately about, the facility. All operations in the facility were suspended pending disposal or repair of the sources and decontamination of the affected facilities.
Apr. 16, 1962	University Park, Pa.			An individual opened a polonium 210 source causing radioactive contamination on surfaces in a laboratory. The opening of this source was not authorized by the license. The licensee has taken steps to improve its surveys for determination of the presence of radioactive contamination.
Apr. 18, 1962	Cambridge, Mass.		915 rem to left hand.	A student working with fission products handled the material with his hands rather than with tongs. New procedures were established by the licensee to assure against a recurrence of such an incident.
Apr. 27, 1962	Houston, Tex.			As a result of a cable break during an oil well logging operation, a 5-curie plutonium-beryllium source was lost in a well. A search and recovery operation retrieved the source from the well two days later.

RADIATION INCIDENTS REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(October 6, 1961-November 30, 1962)

Date of occurrence	Location	Number of persons involved	Extent of exposure	Nature of incident
Apr. 27, 1962	Corpus Christi, Tex.	1	4.2 rem	Exposure occurred when an iridium source became accidentally exposed without the knowledge of radiographic personnel. The specific cause of the accidental exposure was not ascertained during the AEC investigation.
May 11, 1962	Syracuse, N.Y.			About 25 curies of krypton 85 were released to the atmosphere as the result of an equipment malfunction. The loss occurred when an operator failed to detect that an airtight O-ring seal had accidentally been broken prior to his manipulating the equipment. New equipment was put in use by the licensee to prevent a recurrence of such an incident.
May 25, 1962	Erwin, Tenn.			A Teflon valve liner ruptured causing contamination on nearby equipment and floor areas with uranium hexafluoride. The cause of the incident was the failure of a temperature over-ride control which allowed a cylinder of uranium hexafluoride to exceed normal process heat. The licensee took steps to prevent a recurrence of an incident of this type by installing new controls on the equipment.
June 11, 1962	Edgemont, S. Dak.			An estimated 200 to 300 tons of sand tails from a uranium mill were accidentally released into a creek. The release was caused by unusually heavy rainfall which weakened the tailings pile dike. The licensee strengthened the dam retention system and relocated the tailings discharge pipe.
July 12, 1962	Sacramento, Calif.	1	172 rem to hands.	During routine radiography, a pneumatic-type camera containing a 30-curie iridium 192 source malfunctioned. New parts were installed on the malfunctioning camera to prevent a recurrence of this incident.
July 18, 1962	Lorain, Ohio			Twenty cobalt 60 needles were lost during shipment by truck. The loss was the result of the container lid becoming detached during shipment. Sixteen of the cobalt 60 needles were recovered.
July 31, 1962	Orangeburg, N.Y.			During laboratory work with 5 curies of hydrogen 3 as a frozen liquid in a vial, the vial slipped from the fingers of the individual handling the material and fell to the floor. Contamination caused the laboratory to be closed for a period of 24 hours. The incident was the result of a human error. The laboratory was decontaminated.

RADIATION INCIDENTS REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(October 6, 1961–November 30, 1962)

Date of occurrence	Location	Number of persons involved	Extent of exposure	Nature of incident
Aug. 13 through Aug. 24, 1962.	Philadelphia, Pa.	1	5.9 rems	The exposure was received during routine radiography with multi-curie iridium 192 sources. The investigation failed to ascertain the specific cause of the exposure. The licensee was required to correct certain deficiencies in his AEC licensed program which were noted during investigation.
Aug. 20, 1962	Latitude 37°00′ North Longitude 74°37′ West Atlantic Ocean.	----------	----------	While enroute to an authorized sea disposal site, a ship carrying radioactive wastes encountered bad weather. During the storm, 9 drums of wastes containing about 2 curies of radioactivity broke from their chain lashings and slid into the ocean. The depth of the ocean at the point of release is 230 fathoms. Steps were instituted by the licensee to prevent a recurrence.
Sept. 6, 1962	Milwaukee, Wis.	----------	Approximately 1,200 rem to top of the head and 1.8 rem to whole body.	An employee entered a room without knowledge that a 24 curie cobalt 60 source was in the exposed condition. While changing radiography films his head came in close proximity to the exposed source, but remained in that position for only a matter of seconds. The employee was subsequently hospitalized and examination showed no apparent permanent injury. The overexposure was caused by the employee's failure to conduct a physical radiation survey to ascertain the condition of the source before entering the room and the lack of an adequate control device to warn the employee that the source was in fact exposed. The licensee has taken steps to assure against a recurrence of a similar incident.
Sept. 11, 1962	Chicago, Ill.	1	5600 millirem	An employee at a reactor facility was inadvertently overexposed to radiation while performing maintenance on a drain line which was known to be leaking. Although the maintenance was supervised, the employee entered a higher radiation field than was initially anticipated. The leak was subsequently repaired without further incident.
Sept. 17, 1962	Duluth, Minn.	----------	----------	During the routine cleanup of an isotope laboratory, a 12.5 millicurie cobalt 60 source was discarded with incinerator ash to the Duluth Municipal Dump. A subsequent search recovered the source at the dump beneath 8 inches of dirt.

RADIATION INCIDENTS REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(October 6, 1961–November 30, 1962)

Date of occurence	Location	Number of persons involved	Extent of exposure	Nature of incident
Sept. 27, 1962	Attleboro, Mass			Sparks from a deburring operation of an unclad uranium-zirconium enriched fuel plate were drawn into an exhaust system and apparently caused the uranium fines to ignite. The licensee subsequently installed baffles to deflect sparks generated in the deburring operation. About 5 grams of uranium 235 were consumed by fire.
Oct. 4, 1962	Dallas, Tex			During a series of experiments to determine the diffusion of cesium metal into tantalum metal, microcurie quantities of cesium 134 leaked from the sealed tantalum tubes and adhered to the heating coils of a vacuum furnace. The facility was closed for ten days while it was being decontaminated.
Nov. 7, 1962	Wausau, Wis			A package of 10 radiocaps, each containing about 10 microcuries of iodine 131 arrived at the licensee's facility in a damaged condition. An examination of the contents indicated that several of the radiocaps were crushed and that some of the radiocaps were perhaps missing. No contamination was noted in the licensee's facility.
Nov. 9, 1962	Deming, Wash			During an oil well logging operation, a 5 curie plutonium neutron source was lost in a well at a depth of about 600 feet. Attempts to recover the source were unsuccessful and finally abandoned. The licensee cemented the source in place at the bottom of the well.

COMPLIANCE ACTIVITIES

The Commission's Division of Compliance has the functional responsibility for onsite inspections of material and facility licenses and the conduct of investigations of licensee radiation incidents, including those pertaining to the NS *Savannah* and the "second round" reactors, to ascertain the status of compliance with the Commission's rules, regulations, orders, authorizations and license provisions and, to observe and report on the safety of licensed operations.[5]

[5] The Commission's Division of Inspection also exercises certain statutory inspection responsibilities under section 25c of the Atomic Energy Act of 1954, as amended.

Completion of Compliance Field Organizations

During the early part of the calendar year, Compliance Regions were established with regional headquarters at Atlanta, Chicago and Denver. The New York and San Francisco regions had been established previously in 1961. Additional reactor inspectors were reassigned from AEC Headquarters to the regional offices and field investigators were recruited for the field offices to perform investigative functions.

Licensed Facilities

Approximately 255 field inspections were made of operating reactors or those under construction during the calendar year. The reactor inspection staff also participated in public hearings associated with licensing of power reactors and briefed the Commission's Advisory Committee on Reactor Safeguards on significant reactor operating experience. The reactor inspection staff increased from 12 to 14 during 1962.

Significant inspection activities included the continued surveillance of the operation of the Dresden and Yankee power reactors, the NS *Savannah's* reactor, and the initial operations of the Consolidated Edison (Indian Point), Consumers Power (Big Rock Point), Saxton, Consumers Public Power District (Hallam and Rural Cooperative Power Association (Elk River) reactors.

Frequency of inspection visits to operating and building facilities averaged 11 per year for power and test reactors, and one per year for research reactors and critical assembles.

Licensed Materials

The number of specific material licenses on hand as of October 31, 1962, was 8,694, or approximately 16 percent less than the number of licenses on hand beginning January 1, 1962. This number of licenses, which are subject to a regular schedule of inspections, was reduced due to the transfer of jurisdiction over certain byproduct, source and special nuclear materials licenses to the States of Kentucky, Mississippi, California, and New York. During the 12-month period ending September 30, 1962, inspections of 1,820 licenses were completed.

A total of 350 investigations and inquiries was conducted and completed by the field staffs during the 12-month period ended October

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31, 1962. This compares with a total of 349 during the preceding 12 months. As of November 1, 1962, there were 127 investigations and inquiries in some stage of completion.

State Agreements

Close working relationship continued between AEC compliance field personnel and State personnel of agreement and other States to assure continuity of regulatory control of licenses and maximum utilization of Commission field inspection experience.

During 1962 transfer of inspection jurisdiction was made to the States of Kentucky, Mississippi, California, and New York for byproduct material, source material, and special nuclear material in quantities not sufficient to form a critical mass. However, AEC jurisdiction continued with respect to Federal government agencies; export and import; sea disposal; transfer, storage, or disposal of radioactive waste material resulting from separation in a production facility of special nuclear material from irradiated reactor fuel; and transfer of products containing source, byproduct, or special nuclear material intended for use by the general public.

Report on Notification Procedure

During October 1961, a new procedure was adopted whereby a form notice is issued to the licensee upon completion of the inspection bringing to his attention certain readily correctable items of noncompliance. As a result of this new procedure, about 50 percent of the licensee inspections made during 1962 were completed with use of this form. This resulted in prompt notice to licensees of the results of inspections, a reduction in the number of inspection reports previously required to be prepared and in the elimination of correspondence on readily correctable items of noncompliance.

RADIATION PROTECTION STANDARDS

The Commission's Division of Radiation Protection Standards coordinates the AEC's efforts in the development and adoption of radiation protection standards for industrial employees and the general public, and furthering the Commission's policy of relinquishing to qualified States certain regulatory activities.

DEVELOPMENT OF STANDARDS

The Division is responsible for coordinating, within the Commission and with other Federal agencies and outside groups the development and adoption of basic radiation protection standards, and for providing an appropriate degree of mutual compatability between Commission issuances and those of other standards-setting and regulatory groups. The Division provides staff assistance to the Commission with respect to the Federal Radiation Council and represents the Commission at the staff level in the activities of the Council.

FEDERAL RADIATION COUNCIL

The Commission continued its active participation, during 1962, in the Federal Radiation Council which has the statutory responsibility to "advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation wtih States".

Reports

The Council, which includes Atomic Energy Commission representation at the policymaking and working staff levels, continued its review of radiation protection standards and practices during the past year. On June 2, 1962, the Federal Radiation Council released its Report No. 3, "Health Implications of Fallout from Nuclear Weapons Testing Through 1961." [6] The Council also published, on September 17, 1962, a National Academy of Sciences report, "Pathological Effects of Thyroid Irradiation", which had been prepared at the request of FRC for its information and use. Currently, a report on "Background Material for the Development of Radiation Standards for Uranium Mining" is being reviewed by the AEC and other member agencies of the Council.

The Council requested the AEC to undertake a study concerning radioactive material in products for use by the general public. Under contract with AEC's Division of Isotopes Development, a survey of potential uses has been made by the Armour Research Foundation of Chicago. A final report on their survey is in preparation.

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[6] For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., 15 cents.

Exposure Criteria

The Council's annual survey of radiation protection standards promulgated by Federal agencies indicated that, in general, pertinent Federal operating criteria and regulations involve levels consistent with approved Radiation Protection Guides.

Somewhat higher local exposure criteria, however, had been in use relative to nuclear weapons testing, prior to the establishment of the Council. For example, the detonation of a nuclear test device at the Nevada Test Site is scheduled only when meteorological conditions are favorable and estimated offsite radiation exposures subsequent to the test are minimal and within the Radiation Protection Guides. However, local weather changes can and do occasionally occur which could cause offsite exposures significantly above the Guide levels. Prior to a detonation the maximum offsite exposures that could result from credible changes in the current weather situation are estimated. If any individual located offsite is likely to receive a whole body exposure in excess of 3.9 rems in a 1-year period, including prior tests, the test is postponed until more favorable conditions exist. Such criteria were retained for use for the 1961 and 1962 series in the interest of national security.

STATE-AEC RELATIONS

Agreements

During 1962, the following States, pursuant to Section 274 of the Atomic Energy Act of 1954, as amended,[7] entered into agreements with the Commission for the transfer of certain of the Commission's regulatory authority for the control of byproduct material, source material, and special nuclear material in quantities not sufficient to form a critical mass:

State	*Date of Execution*	*Effective Date*
Kentucky	February 8, 1962	March 26, 1962.
California	March 12, 1962 [a]	September 1, 1962.
Mississippi	May 18, 1962	July 1, 1962.
New York	October 15, 1962	October 15, 1962.

[a] Ratified by the California legislature, as required by California law, on April 11, 1962.

A proposal by Texas to enter into an agreement, effective March 1, 1963, has been approved by the Commission and scheduled for execution January 10, 1963.

[7] See pp. 266–267, "Annual Report to Congress for 1959."

Exemptions–10 CFR Part 150

On February 14, 1962, Part 150 of the Code of Federal Regulations, a new AEC regulation, became effective. This Part establishes for persons in Agreement States, certain exemptions from the licensing requirements contained in Chapters 6, 7, and 8 of the Atomic Energy Act, and from the regulations of the Commission. This Part also defines activities in Agreement States over which the regulatory authority of the Commission continues.

Continuing Compatibility

In the interest of maintaining compatibility among the Commission and Agreement State programs, the Commission and Agreement States have recognized the desirability of developing procedures for the collection and exchange of information on their respective programs relating to regulation of the possession and use of atomic energy. Such procedures will include exchange of views on proposed rules, regulations and criteria in connection with licensing, inspection and enforcement. The system would include such other forms of assistance as would enable all parties to be kept fully informed.

As a part of such program to assure continued compatibility, a joint AEC-State meeting was held in Frankfort, Ky., on September 26, 1962, for the purpose of exchanging data and discussing the respective regulatory activities of the AEC and the Commonwealth of Kentucky.

States Preparing for Agreements

In addition to the 4 States which have entered into Agreements with the Commission, 13 other States have enacted enabling legislation which will permit their Governors to execute agreements for the assumption of regulatory authority pursuant to Section 274 of the Atomic Energy Act. They are: Arkansas, Florida, Idaho, Indiana, Louisiana, Maine, Maryland, New Jersey, Oregon, South Carolina, Tennessee, Texas, and Washington. The States of New Jersey, Florida, and Arkansas are actively engaged in the development of radiation control programs for the assumption of regulatory jurisdiction. Texas formally submitted its proposed radiation control program to the Commission early in November.

Suggested State Regulations

Suggested State regulations drafted in 1961 by the AEC, U.S. Public Health Service, and the Council of State Governments, were redrafted during 1962 with the cooperation of the Commission's Advisory Committee of State Officials in light of comments by public and private groups and individuals. These regulations include radiation protection standards, licensing, registration, and intrastate transportation provisions, and cover all sources of radiation within State jurisdiction.

TRAINING ASSISTANCE

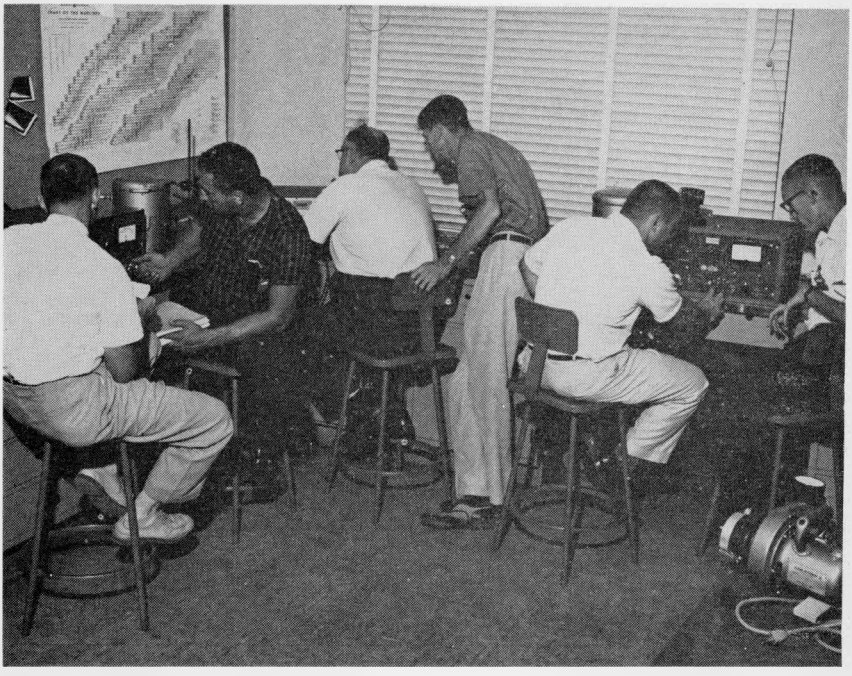
During the calendar year, the Commission's training program in radiological health and licensing was expanded with increased participation by State and local personnel.

Ten-Week Health Physics Course

Beginning September 10, 1962, a 10-week health physics course was repeated by the Oak Ridge Institute of Nuclear Studies in cooperation with the Oak Ridge National Laboratory. This course is primarily for people who will be involved in licensing and inspection at the State and local level. It covers radiation physics fundamentals and instrumentation and includes on-the-job training at Oak Ridge National Laboratory and experiments. Twenty State and local personnel attended the course representing 12 States (Alaska, Wisconsin, New York, Arkansas, Florida, Kentucky, Pennsylvania, New Jersey, Vermont, North Carolina, Indiana, and Maryland).

Special Courses

A pilot program to provide training in radiation protection for those State and local employees who would be unable, because of time and distance, to attend the Ten-week Health Physics Course, was instituted at the Consolidated University of North Carolina in June 1962, with an enrollment of 26. This course is conducted for a period of 4 hours per week and draws its students locally. The course will continue for a period of 1 year and will cover basically the same material provided in the 10-week course. On September 6, 1962, a similar course was begun in Detroit at the University Center of the Universities of Michigan, Eastern Michigan, and Wayne State with an enrollment of 30. Other such courses will be planned as the need arises.



Aid to States. As an aid to States assuming certain of the AEC's regulatory functions for nuclear materials, the Commission held a 10-week health physics course at Oak Ridge National Laboratory during the Fall of 1962. For those State and local government employees who, because of time and distance, could not attend the 10-week course, special regional courses are being set up. These involve 4 hours of training per week over 1 year. Photo shows attendees at the first such course, started in June at North Carolina State College, engaged in a radioactivity counting exercise.

Orientation and Training Courses

Four orientation and training sessions covering the Commission's regulatory program were held at AEC Headquarters in Germantown, Md., ranging from 2 days to 4 weeks. Thirty-one State and local personnel from 10 States participated in this program (Arkansas, California, Florida, Mississippi, New Jersey, New York, North Carolina, Indiana, Illinois, Ohio, and Texas).

Exhibits

A scientific and informational exhibit, designed primarily to inform viewers of the type of AEC assistance available to State and local governments and of the current status of the State-AEC Relations pro



State Assistance Exhibit. As an aid in acquainting State and municipal officials of the types of assistance available from the AEC in regulating atomic energy activities, the Commission uses the above exhibit. It was first displayed during October at the 90th Annual Meeting of the American Public Health Association and at the Annual Meeting of the Florida League of Municipalities in Miami Beach, Fla. One of the features of the exhibit is the map showing the States that have already signed regulatory agreements with the AEC, the States negotiating such agreements, and the States which have passed enabling legislation. On *upper right* is an operating SNAP–3 generator which furnished power to operate a "ham" radio transmitter (partially visible in *lower right*).

gram, was displayed in October 1962, at the 90th Annual Meeting of the American Public Health Association and at the Annual Meeting of the Florida League of Municipalities in Miami Beach, Fla.

Municipal and Local Activities

Local municipal governments demonstrated an increased interest in atomic energy activities during 1962. An increased number of persons from staffs of municipalities and counties have participated in courses on radiation protection sponsored by the Commission.

New York City and Los Angeles have assumed, within the framework of their respective State programs, certain regulatory responsibilities for agreement materials.

During the summer of 1962, members of the American Bridge Tunnel and Turnpike Association provided information to the Commission with respect to regulations of their respective State agencies covering the transportation of radioactive material. A tabulated summary of the information received from 47 of the 61 members is as follows:

No specific regulations in effect	32
Use ICC or modified regulations	11
Prohibitory or restrictive regulations in effect	3
Referred to other State agency	1
TOTAL	47

Notices to State and Local Officials

The Commission amended its regulation 10 CFR Part 2, effective January 13, 1962, to provide for (*a*) formal notice to local officials of the filing of applications for certain facility and waste disposal licenses and amendments to such licenses; and (*b*) AEC notice of hearings to the State, and the chief locality in which the facility is to be located or the activity to be conducted.

State Agreement Resolutions

Various State and local organizations have urged States to enter into agreements with the Commission for assuming regulatory responsibility under Section 274 of the Atomic Energy Act. In April 1962, the National Association of Attorneys General at its 56th annual meeting, adopted a resolution urging the States to accelerate the adoption of such legislation and the development of such programs as will permit them to enter into agreements with the AEC. A similar resolution was adopted by the American Municipal Association at its 39th annual meeting urging that all States assume the responsibilities authorized by P.L. 86–373.

Educational Television

The Commission's Division of Radiation Protection Standards and Division of Public Information cooperated with the Commonwealth of Kentucky in the development of a TV series dealing with the peaceful uses of atomic energy being regulated by the Commonwealth under its agreement with the AEC.

Conferences

The Commission cooperated with the Southern Interstate Nuclear Board in sponsoring a regional conference on "Radiation Control and State-AEC Agreements" which was held in Jackson, Miss., on November 13 and 14, 1962. Individual staff members of the Commission have participated in a number of other conferences and seminars relating to the State-AEC regulatory programs.

Southern Interstate Nuclear Compact

On July 31, 1962, the President approved legislation (P.L. 87–563) granting Congressional consent to the Southern Interstate Nuclear Compact. In consenting to the Compact, Congress declared it to be the national policy to encourage and recognize the performance of functions by the States with respect to the peaceful use of nuclear energy in its several forms; that many programs in nuclear fields can benefit from cooperation among the States, as well as between the Federal Government and the States and that the importance of the interstate compact as one means of promoting such cooperation "is hereby declared a part of the intention of Congress, already expressed in part in Public Law 86–373 to facilitate the use of State jurisdiction in and over portions of the development and regulatory field." Ten States have ratified the Compact (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, South Carolina, Tennessee, Texas, and Virginia).

State Atomic Energy Authorities

In 1962, two States, Kentucky and New York, created atomic energy authorities for the encouragement and development of atomic energy within their respective environs. On March 14, the Governor of Kentucky approved an act establishing a State Atomic Energy Authority which may issue bonds to finance establishment of waste disposal or production facilities and related atomic energy projects. On March 27, 1962, the Governor of New York signed a bill establishing the New York State Atomic Energy Research and Development Authority to encourage and cooperate in the maximum development and use of atomic energy. The Authority received an initial appropriation of $9.3 million and is authorized to issue up to $30 million bonds.

APPENDIX 1

Organization and Principal Staff of U.S. Atomic Energy Commission

Atomic Energy Commission	Glenn T. Seaborg, *Chairman*
	Robert E. Wilson
	Leland J. Haworth
	James T. Ramey
	John G. Palfrey
Secretary to the Commission	W. B. McCool
Chief Hearing Examiner	Samuel W. Jensch
Controller	John P. Abbadessa
General Counsel	Joseph F. Hennessey

OPERATING AND PROMOTIONAL FUNCTIONS

General Manager	A. R. Luedecke
Deputy General Manager	Robert E. Hollingsworth
Assistant General Manager	Dwight A. Ink
Special Assistant (Congressional)	Richard X. Donovan
Director, Division of Public Information.	Duncan C. Clark
Assistant General Manager for Operations.	Edward J. Bloch
Director, Division of Construction	John A. Derry
Director, Division of Contracts	John V. Vinciguerra
Director, Division of Labor Relations.	Oscar S. Smith
Director, Division of Operational Safety.	Nathan H. Woodruff
Assistant General Manager for Research and Development.	Spofford G. English
Director, Division of Biology and Medicine.	Charles L. Dunham, M.D.
Director, Division of Isotopes Development.	Paul C. Aebersold
Director, Division of Reactor Development.	Frank K. Pittman

Director, Division of Research	PAUL W. MCDANIEL
Director, Division of Nuclear Education and Training.	RUSSELL S. POOR
Assistant General Manager for Plans and Production.	GEORGE F. QUINN
Director, Division of Operations Analysis and Forecasting.	PAUL C. FINE
Director, Division of Peaceful Nuclear Explosives.	JOHN S. KELLY
Director, Division of Plans and Reports.	WILLIAM H. SLATON
Director, Division of Production	F. P. BARANOWSKI
Director, Division of Raw Materials.	JESSE C. JOHNSON
Assistant General Manager for International Activities.	ALGIE A. WELLS, *Acting*
Director, Division of International Affairs.	ALGIE A. WELLS
Director, Division of Special Projects.	EDWARD R. GARDNER
Assistant General Manager for Administration.	HARRY S. TRAYNOR
Director, Division of Classification.	C. L. MARSHALL
Director, Division of Headquarters Services.	EDWARD H. GLADE
Director, Division of Intelligence	C. H. REICHARDT
Director, Division of Nuclear Materials Management.	DOUGLAS E. GEORGE
Director, Division of Personnel	ARTHUR L. TACKMAN
Director, Division of Security	JOHN A. WATERS, Jr.
Director, Division of Technical Information.	EDWARD J. BRUNENKANT
Director, Division of Military Application.	MAJ. GEN. AUSTIN W. BETTS
Controller, Office of the Controller	JOHN P. ABBADESSA
General Counsel, Office of the General Counsel.	JOSEPH F. HENNESSEY
Director, Division of Industrial Participation.	ERNEST B. TREMMEL
Director, Division of Inspection	CURTIS A. NELSON

LICENSING AND REGULATORY FUNCTIONS

Director of Regulation	HAROLD L. PRICE
Deputy Director	CLIFFORD K. BECK
Director, Division of Compliance	LAWRENCE D. LOW
Director, Division of Licensing and Regulation.	ROBERT LOWENSTEIN
Director, Division of Radiation Protection Standards.	FORREST WESTERN

MANAGERS OF FIELD OFFICES

Albuquerque (N. Mex.) Operations Office.	KENNER F. HERTFORD
Burlington (Iowa) Area	E. W. GILES
Dayton (Miamisburg, Ohio) Area	WILLIS B. CREAMER
Kansas City (Mo.) Area	WALTER C. YOUNGS, Jr.
Los Alamos (N. Mex.) Area	CHARLES C. CAMPBELL
Pinellas (Fla.) Area	HENRY A. NOWAK
Rocky Flats (Colo.) Area	SETH R. WOODRUFF, Jr.
San Antonio (Tex.) Area	H. JACK BLACKWELL
Sandia (N. Mex.) Area	W. LEE HANCOCK
South Albuquerque (N. Mex.) Area.	WALTER W. STAGG
Brookhaven (Upton, N.Y.) Office	E. L. VAN HORN
Chicago (Ill.) Operations Office	KENNETH A. DUNBAR
Canoga Park (Calif.) Area	JOEL V. LEVY
Grand Junction (Colo.) Office	ALLAN E. JONES
Idaho (Idaho Falls) Operations Office	HUGO N. ESKILDSON, Jr.
Nevada (Las Vegas) Operations Office	JAMES E. REEVES
New York (N.Y.) Operations Office	JOSEPH C. CLARKE
Oak Ridge (Tenn.) Operations Office	S. R. SAPIRIE
Cincinnati (Ohio) Area	CLARENCE L. KARL
New Brunswick (N.J.) Area	C. J. RODDEN
Paducah (Ky.) Area	BERNARD N. STILLER
Portsmouth (Ohio) Area	ROY V. ANDERSON
Puerto Rico (San Juan) Area	FLOYD P. TRENT
St. Louis (Mo.) Area	FRED H. BELCHER
Pittsburgh (Pa.) Naval Reactors Office.	LAWTON D. GEIGER
Richland (Wash.) Operations Office	J. E. TRAVIS
San Francisco (Calif.) Operations Office.	ELLISON C. SHUTE
Palo Alto (Calif.) Area	LAWRENCE G. MOHR

Savannah River (Aiken, S.C.) Operations Office.	ROBERT C. BLAIR
Schenectady (N.Y.) Naval Reactors Office.	STANLEY W. NITZMAN

DIRECTORS OF COMPLIANCE FIELD ORGANIZATIONS

Region I (New York)	ROBERT W. KIRKMAN
Region II (Atlanta)	GENE A. BLANC
Region III (Chicago)	ROY C. HAGEMAN
Region IV (Denver)	DONALD I. WALKER
Region V (San Francisco)	RICHARD W. SMITH

PRINCIPAL AEC REPRESENTATIVES IN FOREIGN OFFICES

Brussels, Belgium	JOHN ERLEWINE
Buenos Aires, Argentina	RAYMOND R. BEARD, *Acting*
Chalk River, Ontario, Canada	Vacancy
London, England	SAMUEL G. NORDLINGER
Paris, France	ABRAHAM S. FRIEDMAN
Tokyo, Japan	IRA F. ZARTMAN

APPENDIX 2

MEMBERSHIP OF COMMITTEES

STATUTORY COMMITTEES AND BOARD

Joint Committee on Atomic Energy—Eighty-eighth Congress

This committee was established by the Atomic Energy Act of 1946, and continued under the Atomic Energy Act of 1954, to make "continuing studies of the activities of the Atomic Energy Commission and of problems relating to the development, use, and control of atomic energy." The committee is kept fully and currently informed with respect to the Commission's activities. Legislation relating primarily to the Commission or to atomic energy matters is referred to the committee. The committee's membership is composed of 9 Members of the Senate and 9 Members of the House of Representatives.

Senator JOHN O. PASTORE (Rhode Island), *Chairman.*
Representative CHET HOLIFIELD (California), *Vice Chairman.*
Senator CLINTON P. ANDERSON (New Mexico).
Senator RICHARD B. RUSSELL (Georgia).
Senator ALBERT GORE (Tennessee).
Senator HENRY M. JACKSON (Washington).
Senator BOURKE B. HICKENLOOPER (Iowa).
Senator GEORGE D. AIKEN (Vermont).
Senator WALLACE F. BENNETT (Utah).
Senator EVERETT M. DIRKSEN (Illinois).
Representative MELVIN PRICE (Illinois).
Representative WAYNE N. ASPINALL (Colorado).
Representative ALBERT THOMAS (Texas).
Representative CRAIG HOSMER (California).
Representative WILLIAM H. BATES (Massachusetts).
Representative JACK WESTLAND (Washington).
Representative THOMAS G. MORRIS (New Mexico).
Representative (Vacancy).
JOHN T. CONWAY, *Executive Director.*

Military Liaison Committee

Under section 27 of the Atomic Energy Act of 1954, "there is hereby established a Military Liaison Committee consisting of—*a.* a Chairman, who shall be the head thereof and who shall be appointed by the President, by and with the advice and consent of the Senate, who shall serve at the pleasure of the President, and who shall receive compensation at the rate prescribed for an Assistant Secretary of Defense; and *b.* a representative or representatives from each of the Departments of the Army, Navy, and Air Force, in equal numbers as determined by the Secretary of Defense, to be assigned from each Department by the Secretary thereof, and who will serve without additional compensation. The Chairman of the Committee may designate one of the members of the Committee as Acting Chairman to act during his absence. The Commission shall advise and consult with the Department of Defense, through the Committee, on all

atomic energy matters which the Department of Defense deems to relate to military applications of atomic weapons or atomic energy including the development, manufacture, use, and storage of atomic weapons, the allocation of special nuclear material for military research, and the control of information relating to the manufacture or utilization of atomic weapons; and shall keep the Department of Defense, through the Committee, fully and currently informed of all such matters before the Commission. The Department of Defense, through the Committee, shall keep the Commission fully and currently informed on all matters within the Department of Defense which the Commission deems to relate to the development or application of atomic energy. The Department of Defense, through the Committee, shall have the authority to make written recommendations to the Commission from time to time on matters relating to military applications of atomic energy as the Department of Defense may deem appropriate. If the Department of Defense at any time concludes that any request, action, proposed action, or failure to act on the part of the Commission is adverse to the responsibilities of the Department of Defense, the Secretary of Defense shall refer the matter to the President whose decision shall be final."

Hon. GERALD W. JOHNSON, *Chairman*
Maj. Gen. EDWIN B. BROADHURST, United States Air Force
Maj. Gen. JAMES F. WHISENAND, United States Air Force
Rear Adm. WILLIAM E. ELLIS, United States Navy
Brig. Gen. WALTER B. RICHARDSON, United States Army
Brig. Gen. WILLIAM T. RYDER, United States Army
Capt. EDWARD E. CONRAD, United States Navy

General Advisory Committee

This committee was established by the Atomic Energy Act of 1946, and is continued by the Atomic Energy Act of 1954. The nine civilian members are appointed by the President to advise the Commission on scientific and technical matters relating to materials, production, and research and development. Under the Atomic Energy Act, the committee shall meet at least four times in every calendar year.

Dr. MANSON BENEDICT, *chairman;* professor of nuclear engineering, Massachusetts Institute of Technology, Cambridge, Mass.
Dr. PHILIP H. ABELSON, director, geophysical laboratory, Carnegie Institution, Washington, D.C.
Dr. L. R. HAFSTAD, vice president, research laboratories, General Motors Corp., Warren, Mich.
Dr. KENNETH S. PITZER, president, Rice University, Houston, Tex.
Dr. NORMAN F. RAMSEY, department of physics, Harvard University, Cambridge, Mass.
Dr. J. C. WARNER, president, Carnegie Institute of Technology, Pittsburgh, Pa.
Dr. EUGENE P. WIGNER, Palmer physical laboratory, Princeton University, Princeton, N.J.
Dr. JOHN H. WILLIAMS, school of physics, University of Minnesota, Minneapolis, Minn.
Vacancy.*
Dr. ROBERT A. CHARPIE, *secretary;* Union Carbide Corp., New York, N.Y.

*Vacancy due to death of Eger V. Murphree, October 1962.

Patent Compensation Board

This Board was established in April 1949 pursuant to Section 11 of the Atomic Energy Act of 1946, and is the Board designated under Section 157a of the Atomic Energy Act of 1954. Section 157 provides that upon application for just compensation or awards or for the determination of a reasonable royalty fee certain proceedings shall be held before such a Board.

ROBERT C. WATSON, *chairman;* firm of Watson, Cole, Grindle & Watson, Washington, D.C.

DOUGLAS MCLEOD COOMBS, Simmonds Precision Products, Inc., Tarrytown, N.Y.

MALCOLM W. FRASER, private practice of patent law, Toledo, Ohio.

HERMAN I. HERSH, firm of Ooms, McDougall & Hersh, Chicago, Ill.

LAWRENCE C. KINGSLAND, firm of Kingsland, Rogers, Ezell and Robbins, St. Louis, Mo.

GEORGE SIPKIN, private practice of law, Miami, Fla.

Advisory Committee on Reactor Safeguards

The Committee reviews safety studies and facility license applications referred to it and makes reports thereon, advises the Commission with regard to the hazards of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards, and performs such other duties as the Commission may request. The Committee's reports on applications for facility licenses become a part of the record of the application and available to the public, except for security material. Members are appointed by the Commission for a term of four years each, and one member is designated by the committee as its chairman. This statutory committee replaced the former Advisory Committee on Reactor Safeguards in 1957.

Dr. FRANKLIN A. GIFFORD, Jr., *chairman;* meteorologist-in-charge, Weather Bureau Research Station, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

Dr. HENRY W. NEWSON, *vice-chairman;* professor of physics, Duke University, Durham, N.C.

Dr. WILLIAM K. ERGEN, principal physicist, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. JOHN C. GEYER, chairman, department of sanitary engineering and water resources, The Johns Hopkins University, Baltimore, Md.

Dr. DAVID B. HALL, division leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. JOHN P. HOWE, director, department of engineering physics and materials science, Cornell University, Ithaca, N.Y.

Dr. HERBERT J. C. KOUTS, nuclear engineering department, Brookhaven National Laboratory, Upton, N.Y.

KENNETH R. OSBORN, director, industrial development, General Chemical Division, Allied Chemical Corp., Morristown, N.J.

DONALD A. ROGERS, consultant, Morristown, N.J.

Dr. LESLIE SILVERMAN, professor of engineering in environmental hygiene and director of radiological hygiene program, Harvard University, Boston, Mass.

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REUEL C. STRATTON, consulting engineer, Hartford, Conn.

Dr. THEOS J. THOMPSON, director, MIT nuclear reactor, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. CHARLES R. WILLIAMS, assistant vice president, Liberty Mutual Insurance Co., Boston, Mass.

Dr. DICK DUFFEY, *technical secretary;* professor of nuclear engineering, University of Maryland, College Park, Md.

JAMES B. GRAHAM, *executive secretary;* U.S. Atomic Energy Commission, Washington, D.C.

ATOMIC ENERGY LABOR-MANAGEMENT RELATIONS PANEL

The members of this panel were selected by the President to assist in arriving at peaceful adjustments of labor-management disputes which would imperil the Government's atomic energy program when the normal processes of collective bargaining and mediation have been fully utilized without constructive results. The panel operates under procedures designed to accomplish this purpose.

CYRUS S. CHING, *chairman;* industrial relations consultant and former Director of the Federal Mediation and Conciliation Service, Washington, D.C.

Rev. LEO C. BROWN, S.J., professor of economics and director of the Institute of Social Order, St. Louis University, St. Louis, Mo.

Vice Adm. O. S. COLCLOUGH, USN, Retired, dean of faculties, the George Washington University, Washington, D.C.

ROBBEN W. FLEMING, professor of law, University of Illinois, Urbana, Ill.

CHARLES O. GREGORY, professor of law, University of Virginia, Charlottesville, Va.

ABE MURDOCK, former U.S. Senator and Member of National Labor Relations Board, Washington, D.C.

RUSSELL A. SMITH, professor of law and secretary of University of Michigan Law School, Ann Arbor, Mich.

DAVID H. STOWE, labor arbitrator and former Administrative Assistant to the President, Washington, D.C.

ADVISORY BODIES TO THE ATOMIC ENERGY COMMISSION

Advisory Committee for Biology and Medicine

The Advisory Committee for Biology and Medicine was created in September 1947, on the recommendation of the Commission's Medical Board of Review. The committee reviews the programs in medical and biological research and health and recommends to the Commission general policies in these fields.

Dr. H. BENTLEY GLASS, *chairman,* professor of biology, Johns Hopkins University, Baltimore, Md.

Dr. JAMES G. HORSFALL, *vice-chairman,* director, Connecticut Agricultural Experiment Station, New Haven, Conn.

Dr. FRED J. HODGES, professor and chairman of radiology, department of radiology, University of Michigan Medical Center, Ann Arbor, Mich.

Dr. ROBERT F. LOEB, bard professor of medicine, Columbia University, New York, N.Y.

Dr. LEONIDAS D. MARINELLI, associate director, radiological physics division, Argonne National Laboratory, Argonne, Ill.

Dr. CARL V. MOORE, professor of medicine, department of internal medicine, Washington University, Barnes & Wohl Hospital, St. Louis, Mo.

Dr. JAMES H. STERNER, medical director, Eastman Kodak Co., Rochester, N.Y.

(2 vacancies)

Historical Advisory Committee

The Historical Advisory Committee was established by the Commission in February, 1958, to advise the Commission and its historical staff on matters relating to the preparation of the history of the Atomic Energy Commission.

Dr. JAMES P. BAXTER, III, *chairman*, senior fellow, Council on Foreign Relations, Inc., New York, N.Y.

Dr. JAMES L. CATE, professor of history, University of Chicago, Chicago, Ill.

Dr. RALPH W. HIDY, professor of business history, Graduate School of Business Administration, Harvard University, Cambridge, Mass.

Dr. GEORGE E. MOWRY, professor and chairman of the history department, University of California, Los Angeles, Calif.

Dr. ISADORE PERLMAN, associate director, Lawrence Radiation Laboratory, University of California, Berkeley, Calif.

DON K. PRICE, Jr., dean, Graduate School of Public Administration, Harvard University, Cambridge, Mass.

Dr. ROBERT R. WILSON, director, Laboratory of Nuclear Studies, Cornell University, Ithaca, N.Y.

Dr. RICHARD G. HEWLETT, AEC representative, chief historian, U.S. Atomic Energy Commission, Washington, D.C.

Advisory Committee on Isotope and Radiation Development

This Committee was established by the Commission in July 1958 to advise on means of encouraging widescale industrial use of radioisotopes and nuclear radiation.

Dr. PAUL C. AEBERSOLD, *chairman;* director, division of isotopes development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. JAMES F. BLACK, senior research associate, products research division, Esso Research and Engineering Co., Linden, N.J.

LAUCHLIN M. CURRIE, North Carolina Research Triangle, New York, N.Y.

Dr. HENRY J. GOMBERG, deputy director, Puerto Rico Nuclear Center, College Station, Mayaguez, Puerto Rico.

JOHN J. GREBE, director, nuclear and basic research, Dow Chemical Co., Midland, Mich.

Dr. MOSES A. GREENFIELD, department of radiology, University of California, Los Angeles, Calif.

JOHN L. KURANZ, vice president, Nuclear-Chicago Corp., Des Plaines, Ill.

Dr. CLARENCE E. LARSON, vice president, Union Carbide Nuclear Co., Oak Ridge, Tenn.

Dr. W. WAYNE MEINKE, department of Chemistry, University of Michigan, Ann Arbor, Mich.

HOMER S. MYERS, Spindletop Research, Inc., Lexington, Ky.

Dr. LEONARD REIFFEL, director of physics research, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

OLIVER H. TOWNSEND, director, Office of Atomic Development, State of New York, New York City.

Advisory Committee on Medical Uses of Isotopes

This committee was established in 1958 and replaces the Subcommittee on Human Applications of the Advisory Committee on Isotope Distribution. The committee will advise the Commission on policies and standards for the regulation and licensing of medical uses of radioisotopes in humans.

Dr. WALLACE D. ARMSTRONG, professor, department of biochemistry, University of Minnesota Medical School, Minneapolis, Minn.

Dr. REYNOLD F. BROWN, department of radiology, University of California Medical School, San Francisco, Calif.

Dr. DONALD S. CHILDS, Jr., section of therapeutic radiology, Mayo Clinic, Rochester, Minn.

Dr. JOHN A. D. COOPER, assistant dean, Northwestern University Medical School, Chicago, Ill.

Dr. GEORGE V. LEROY, associate dean, division of biological sciences, University of Chicago, Chicago, Ill.

Dr. EDITH H. QUIMBY, associate professor of radiology, College of Physicians and Surgeons, Columbia University, New York, N.Y.

Dr. RULON W. RAWSON, Memorial Hospital, New York, N.Y.

Plowshare Advisory Committee

The Plowshare Advisory Committee was established in September 1959. The committee's function is to advise the Commission and the General Manager on selecting and carrying out particular Plowshare projects; developing and making available various applications of Plowshare; and determining the general orientation and policies of the Plowshare program.

Dr. SPOFFORD G. ENGLISH, *chairman*, assistant general manager for research and development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. PHILIP H. ABELSON, director, geophysical laboratory, Carnegie Institution, Washington, D.C.

WILLARD BASCOM, president, Ocean Science & Engineering, Inc., Washington, D.C.

Lt. Gen. JAMES H. DOOLITTLE, Space Technology Laboratories, Inc., Los Angeles, Calif.

Dr. LOUIS H. HEMPELMANN, school of medicine and dentistry, University of Rochester, Rochester, N.Y.

Dr. RICHARD LATTER, The Rand Corp., Santa Monica, Calif.

Dr. WILLARD F. LIBBY, department of chemistry, University of California, Los Angeles, Calif.

Dr. W. RANDOLPH LOVELACE, II, Lovelace Foundation, Albuquerque, N. Mex.

Dr. DONALD H. MCLAUGHLIN, president, Homestake Mining Co., San Francisco, Calif.

Dr. PHILIP C. RUTLEDGE, partner, Moran, Proctor, Mueser & Rutledge, New York, N.Y.

Dr. PAUL B. SEARS, professor emeritus and former chairman, conservation program, Yale University, New Haven, Conn.

Dr. ABEL WOLMAN, professor sanitary engineering, The Johns Hopkins University, Baltimore, Md.

Advisory Committee on Reactor Physics

This committee is appointed to consider the status of the development of reactor physics information required for the development of reactor concepts and the design and construction of reactors. Nuclear physics data and reactor physics studies required for the design and development of reactors and reviewed and evaluated. The committee's recommendations and advice are used in planning the research and development work in the field of reactor physics.

PHILIP B. HEMMIG, *chairman*, division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ROBERT AVERY, head of theoretical physics group, reactor division, Argonne National Laboratory, Argonne, Ill.

JACK CHERNICK, associate head, reactor physics division, Brookhaven National Laboratory, Upton, N.Y.

Dr. EMMANUEL R. COHEN, research advisor, Atomics International, North American Aviation, Inc., Canoga Park, Calif.

DESLONDE DEBOISBLANC, director, reactor physics and engineering, Phillips Petroleum Co., Idaho Falls, Idaho.

Dr. GERHARD DESSAUER, director, physics section, E. I. du Pont de Nemours & Co., Inc., Aiken, S.C.

Dr. MILTON EDLUND, manager, physics and mathematics department, Babcock & Wilcox Co., Lynchburg, Va.

Dr. RICHARD EHRLICH, manager, advanced development activity, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N.Y.

Dr. PAUL F. GAST, manager, physics and instruments, General Electric Co., Richland, Wash.

Dr. GORDON HANSEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. IRVING KAPLAN, professor, department of engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. SIDNEY KRASIK, manager, NERVA Project, Westinghouse Electric Corp., Pittsburgh, Pa.

Dr. F. C. MAIENSCHEIN, associate director, neutron physics division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. THOMA M. SNYDER, manager, physics—APED, Vallecitos Atomic Laboratory, General Electric Co., Pleasanton, Calif.

JOHN J. TAYLOR, manager, Reactor Development & Analysis Department, Bettis Atomic Power Div., Westinghouse Electric Corp, Pittsburgh, Pa.

Dr. PAUL F. ZWEIFEL, professor, department of nuclear engineering, University of Michigan, Ann Arbor, Mich.

Dr. ALVIN RADKOWSKY, secretary; division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Advisory Committee for Standard Reference Materials and Methods of Measurement

The committee was originally established by the Commission in March 1956, as the Committee for Uranium Isotopic Standards. The Commission approved its reconstitution in January 1958, under its present title, to reflect the broadened scope of its activities. The committee reviews, evaluates and recommends means for providing standard reference materials (*i.e.*, certified chemical and isotopic standards for uranium, plutonium, etc.) and approved methods of measurement for materials of special importance to atomic energy activities.

Dr. SAMUEL C. T. MCDOWELL, *chairman*, deputy director, division of nuclear materials management, U.S. Atomic Energy Commission, Washington, D.C.

RALPH J. JONES, division of nuclear materials management, U.S. Atomic Energy Commission, Washington, D.C.

Dr. CHARLES F. METZ, group leader, analytical chemistry group, chemistry and metallurgical research division, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. HORACE W. NORTON, III, professor of statistical design and analysis, University of Illinois, Urbana, Ill.

Dr. LEONARD P. PEPKOWITZ, vice president, Nuclear Materials and Equipment Corp., Apollo, Pa.

C. J. RODDEN, area manager, New Brunswick Area Office, U.S. Atomic Energy Commission, New Brunswick, N.J.

CHARLES M. STEVENS, special materials and services, Argonne National Laboratory, Argonne, Ill.

Dr. JOHN K. TAYLOR, National Bureau of Standards, Department of Commerce, Washington, D.C.

C. D. W. THORNTON, International Telephone and Telegraph Corp., New York, N.Y.

Dr. EDWARD WICHERS, National Academy of Sciences, Washington, D.C.

Advisory Committee of State Officials

This committee was established by the Commission in September 1955 as a means of obtaining the views and advice of State regulatory agencies in connection with the Atomic Energy Commission's regulatory activities in the field of public health and safety. In 1960 its function was enlarged to furnish guidance in the implementation of the Commission's program of cooperation with States. At the same time, its membership was broadened to provide a larger cross section of views consistent with its additional functions.

THE HONORABLE JOHN B. BRECKINRIDGE, attorney general of Kentucky, Frankfort, Ky.

Dr. BERNARD BUCOVE, director of health, State Department of Health, Seattle, Wash.

Dr. R. L. CLEERE, executive director, State Department of Public Health, Denver, Colo.

THE HONORABLE NORMAN A. ERBE, governor of Iowa, Des Moines, Iowa.

CURTISS M. EVERTS, Jr., State sanitary engineer, Oregon State Board of Health, Portland, Oreg.

CARL FRASURE, committee of State officials on suggested State legislation, West Virginia University, Morgantown, W. Va.

ALEXANDER GRENDON, coordinator of atomic energy development and radiation protection, State of California, Sacramento, Calif.

Dr. ALBERT E. HEUSTIS, commissioner of health, Michigan Department of Health, Lansing, Mich.

Dr. HERMAN E. HILLEBOE, commissioner of health, State Department of Health, Albany, N.Y.

C. W. KLASSEN, chief sanitary engineer, Department of Public Health, Springfield, Ill.

Dr. MORRIS KLEINFELD, director, division of industrial hygiene, Department of Labor, New York, N.Y.

W. T. LINTON, executive director, water pollution control authority, South Carolina State Board of Health, Columbia, S.C.

HENRY M. MARX, coordinator, Atomic Development Activities, Greenwich, Conn.

KARL M. MASON, director, bureau of environmental health, Pennsylvania Department of Health, Harrisburg, Pa.

Dr. JAMES E. PEAVY, commissioner of health, State Department of Health, Austin, Tex.

WILLIAM J. PIERCE, national conference of commissioners on uniform laws, University of Michigan Law School, Ann Arbor, Mich.

B. A. POOLE, director, bureau of environmental sanitation, Indiana State Board of Health, Indianapolis, Ind.

RAYMOND I. RIGNEY, coordinator of atomic development, The Commonwealth of Massachusetts, Boston, Mass.

D. P. ROBERTS, chief industrial hygiene section, Tennessee Department of Health, Nashville, Tenn.

ROBERT H. SOLOMONS, III, executive director, Southern Interstate Nuclear Board, Atlanta, Ga.

OLIVER TOWNSEND, director, Office of Atomic Development, New York, N.Y.

Advisory Committee on Technical Information

This committee was established during 1961, replacing the Advisory Committee on Industrial Information, formed in 1949. The Committee advises and assists in the planning and execution of the AEC's technical information program.

EDWARD J. BRUNENKANT, *chairman;* director, division of technical information, U.S. Atomic Energy Commission, Washington, D.C.

HERBERT S. BAILEY, Jr., director, Princeton University Press, Princeton, N.J.

JOHN E. DOBBIN, project director, Educational Testing Service, Princeton N.J.

BERNARD M. FRY, deputy head, office of science information service, National Science Foundation, Washington, D.C.

JAMES L. GAYLORD, senior partner of James L. Gaylord Associates, Santa Monica, Calif.

Dr. ALLEN G. GRAY, editor, "Metal Progress", American Society for Metals, Novelty, Ohio.

EUGENE J. HARDY, assistant vice-president, National Association of Manufacturers, Washington, D.C.

NORMAN H. JACOBSON, executive business editor, "Electric Light and Power", Haywood Publishing Co., Chicago, Ill.

ANDREW W. KRAMER, editor, "Atomics," The Technical Publishing Co., Barrington, Ill.

JOHN W. LANDIS, manager, Atomic Energy Division, The Babcock & Wilcox Co., Lynchburg, Va., representing American Nuclear Society, Chicago, Ill.

FREDERIC A. PAWLEY, research secretary, American Institute of Architects, Washington, D.C.

KARL T. SCHWARTZWALDER, director of research, A–C spark plug division, General Motors Corp., Flint, Mich., representing The American Ceramic Society, Inc., Columbus, Ohio.

OLIVER H. TOWNSEND, director, Office of Atomic Development, State of New York, New York City.

STANLEY A. TUCKER, representing American Society of Mechanical Engineers, New York, N.Y.

JOHN W. WIGHT, vice president, McGraw-Hill Book Co., Inc., New York, N.Y.

Committee of Senior Reviewers

The Committee of Senior Reviewers studies the major technical activities of the Atomic Energy Commission program and advises the Commission on classification and declassification matters, making recommendations with respect to the rules and guides for the control of scientific and technical information. The Committee consists of eight members appointed for a term of 5 years on a rotating basis.

Dr. ALVIN C. GRAVES, *chairman;* J division leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. EUGENE EYSTER, alternate GMX division leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. A. C. HAUSSMANN, A division leader, Lawrence Radiation Laboratory, University of California, Livermore, Calif.

Dr. JOHN P. HOWE, professor of engineering, Cornell University, Ithaca, N.Y.

Dr. FRANK C. HOYT, missiles system division, Lockheed Aircraft Corp., Palo Alto, Calif.

Dr. WARREN C. JOHNSON, vice president, University of Chicago, Chicago, Ill.

Dr. WINSTON M. MANNING, director, chemistry division, Argonne National Laboratory, Lemont, Ill.

Dr. J. REGINALD RICHARDSON, professor of physics, University of California at Los Angeles, Calif.

Nuclear Cross Sections Advisory Group

This group is appointed on a yearly basis to make a continuing review of the Commission's program of nuclear cross-section measurements, and to evaluate the needs for cross-section information in the various activities of the Commission.

Dr. VANCE L. SAILOR, *chairman;* Brookhaven National Laboratory, Upton, Long Island, N.Y.

Dr. ROBERT COTE, Argonne National Laboratory, Argonne, Ill.

Dr. HERMAN J. DONNERT, Army Chemical Center, Defense Atomic Support Agency, Washington, D.C.

Dr. STANLEY C. FULTZ, Lawrence Radiation Laboratory, University of California, Livermore, Calif.

ERWIN GAERTTNER, professor, Rensselaer Polytechnic Institute, Troy, N.Y.

Dr. HERBERT GOLDSTEIN, department of physics, Columbia University, New York City.

PHILIP B. HEMMIG, division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. BOWEN R. LEONARD, Hanford Laboratories, General Electric Co. Hanford, Wash.

Dr. LEON J. LIDOFSKY, department of physics, Columbia University, New York, N.Y.

Dr. MICHAEL S. MOORE, Phillips Petroleum Co., Idaho Falls, Idaho
Dr. HENRY W. NEWSON, department of physics, Duke University, Durham, N.C.
Dr. GERALD C. PHILLIPS, William Marsh Rice University, Houston, Tex.
Dr. GEORGE L. ROGOSA, division of research, U.S. Atomic Energy Comission, Washington, D.C.
Dr. ERWIN F. SHRADER, department of physics, Case Institute of Technology, Cleveland, Ohio
Dr. RICHARD F. TASCHEK, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. HARVEY WILLARD, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Dr. CLAY ZERBY, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Dr. JOHN R. STEHN, *secretary;* Brookhaven National Laboratory, Upton, Long Island, N.Y.

Personnel Security Review Board

This board was appointed in March 1949 primarily to review specific personnel security cases which arise under the Commission's administrative review procedure and to make recommendations concerning them to the General Manager. The board also advises the Commission on the broader considerations regarding personnel security, such as criteria for determining eligibility for security clearance and personnel security procedures.

GANSON PURCELL, *chairman;* Purcell & Nelson, Washington, D.C.
JOHN J. WILSON, firm of Whiteford, Hart, Carmody & Wilson, Washington, D.C.
Vacancy.

APPENDIX 3

Major Research and Development Installations of the U.S. Atomic Energy Commission

Ames Laboratory (Iowa State University of Science and Technology, contractor), Ames, Iowa

Director	Dr. Frank H. Spedding
Associate Director	Dr. H. A. Wilhelm
Assistant Director	Dr. Adolph F. Voigt
Assistant Director	Dr. Morton Smutz
Business Manager	Alex E. Edwards

Argonne Cancer Research Hospital (University of Chicago, contractor), Chicago, Ill.

Director	Dr. Leon O. Jacobson
Associate Director	Dr. Robert J. Hasterlik
Assistant Director for Administration	Cyril W. Kupferberg

Argonne National Laboratory (University of Chicago, contractor), Lemont, Ill.

Director	Dr. Albert V. Crewe
Deputy Director	Dr. Louis A. Turner
Associate Director for Education	Dr. Frank E. Myers
Associate Director for High Energy Physics	Dr. Roger H. Hildebrand
Assistant Director	Dr. James R. Gilbreath
Business Manager	John H. McKinley
Manager, Technical Services	John T. Bobbitt

Associated Midwest Universities:

President, Board of Directors	W. L. Everitt
Vice President	W. R. Marshall
Executive Director	J. H. Roberson
Treasurer	A. T. Schmehling

The participating institutions are:

Battelle Memorial Institute
Carnegie Institute of Technology
Case Institute of Technology
Illinois Institute of Technology
Indiana University
Iowa State University
Kansas State University
Loyola University (Chicago, Ill.)
Marquette University
St. Louis University
State University of Iowa
University of Chicago
University of Cincinnati
University of Illinois
University of Kansas
University of Michigan
University of Minnesota
University of Missouri

Mayo Foundation
Michigan College of Mining and Technology
Michigan State University
Northwestern University
Ohio State University
Oklahoma State University
Purdue University
University of Nebraska
University of Notre Dame
University of Wisconsin
Washington University (St. Louis)
Wayne University
Western Reserve University

Bettis Atomic Power Laboratory (Westinghouse Electric Corp., contractor), Pittsburgh, Pa.

General Manager	PHILLIP N. ROSS
Manager, PWR Project	J. T. STIEFEL
Manager, Surface Ship Project	ELLIS T. COX
Manager, Submarine Project	N. A. BELDECOS
Manager, Naval Reactor Facility (NRTS), Idaho.	D. C. SPENCER

Brookhaven National Laboratory (Associated Universities, Inc., contractor), Upton, Long Island, N.Y.

Chairman, Board of Trustees	DR. I. I. RABI
President, AUI	DR. G. F. TAPE
Laboratory Director	DR. MAURICE GOLDHABER
Deputy Director	DR. CLARKE WILLIAMS
Associate Director	DR. CHARLES E. FALK
Assistant Director	DR. R. CHRISTIAN ANDERSON
Assistant Director	SAMUEL M. TUCKER
Assistant Director	DR. G. NORRIS GLASOE

The participating institutions are:
Columbia University
Cornell University
Harvard University
The Johns Hopkins University
Massachusetts Institute of Technology
Princeton University
University of Pennsylvania
University of Rochester
Yale University

Hanford Laboratories—Hanford Atomic Products Operation (General Electric Co., contractor), Richland, Wash.

Manager, Hanford Laboratories	H. M. PARKER
Manager, Chemical Research Development	DR. W. H. REAS
Manager, Reactor and Fuels Research & Development.	Dr. F. W. ALBAUGH
Manager, Physics and Instruments Research and Development.	Dr. P. F. GAST
Manager, Operations Research and Synthesis	Dr. C. A. BENNETT
Manager, Biology	Dr. H. A. KORNBERG
Manager, Radiation Protection	A. R. KEENE
Manager, Programming	Dr. W. K. WOODS
Manager, Test Reactor and Auxiliaries Operation.	W. D. RICHMOND

Knolls Atomic Power Laboratory (General Electric Co., contractor), Schenectady, N.Y.

General Manager	B. H. CALDWELL, Jr.
Manager, D1G Project	K. A. KESSELRING
Manager, NCR Project	J. D. SELBY
Manager, SAR Project	E. C. RUMBAUGH

Los Alamos Scientific Laboratory (University of California, contractor), Los Alamos, N. Mex.

Director	Dr. NORRIS E. BRADBURY
Technical Associate Director	Dr. RAEMER E. SCHRIEBER

Mound Laboratory (Monsanto Research Corp., contractor), Miamisburg, Ohio

Project Director (President, Monsanto Research Corp.).	H. K. NASON
Plant Manager (Vice President, Monsanto Research Corp.).	DAVID L. SCOTT

National Reactor Testing Station (NRTS) Idaho Falls, Idaho (three contractors)

Phillips Petroleum Co., Atomic Energy Division, Idaho Falls

Project Manager	Dr. R. L. DOAN
Deputy Manager	J. P. LYON
Assistant Manager, Operations	M. H. BARTZ
Assistant Manager, Technical	J. R. HUFFMAN
Assistant Manager, Engineering	L. J. WEBER
Assistant Manager, Administration	L. L. LEEDY

Aerojet General Corp. and Aerojet General Nucleonics, San Ramon, Calif.

Operations Manager	R. H. CHESWORTH
Operations Superintendent	D. C. KING
Administrative Supervisor	C. NEDROW

General Electric Co. (Idaho Test Station, Nuclear Materials and Propulsion Operation, Flight Propulsion Laboratory Dept.), Idaho Falls

Manager	Dr. J. W. MORFITT
Manager, SL-1 Project	Dr. C. L. STORRS
Manager, Engineering	Dr. R. E. WOOD
Manager, Administrative	R. M. HOWES

Oak Ridge Institute of Nuclear Studies (contractor), Oak Ridge, Tenn.

President of Institute	DR. PAUL M. GROSS
Executive Director of Institute	DR. WILLIAM G. POLLARD
Chairman of Council	DR. R. T. LAGEMANN
Vice Chairman of Council	DR. ERIC RODGERS

The sponsoring universities of the Institute are:

Agricultural and Mechanical College of Texas	Tuskegee Institute
Alabama Polytechnic Institute	University of Alabama
Catholic University of America	University of Arkansas
Clemson Agricultural College	University of Florida
Duke University	University of Georgia
Emory University	University of Kentucky
Fish University	University of Louisville
Florida State University	University of Maryland
Georgia Institute of Technology	University of Miami
Louisiana State University	University of Mississippi
Meharry Medical College	University of North Carolina
Mississippi State College	University of Oklahoma
North Carolina State College	University of Puerto Rico
North Texas State College	University of South Carolina
Rice Institute	University of Tennessee
Southern Methodist University	University of Texas
Texas Christian University	University of Virginia
Texas Woman's University	Vanderbilt University
Tulane University of Louisiana	Virginia Polytechnic Institute
	West Virginia University

Oak Ridge National Laboratory (Union Carbide Nuclear Co., Division of Union Carbide Corp., contractor), Oak Ridge, Tenn.

Director	A. M. WEINBERG
Deputy Director	A. J. SWARTOUT
Assistant Deputy Director	F. R. BRUCE
Associate Director	H. G. MACPHERSON
Assistant Director	G. E. BOYD
Assistant Director	R. W. JOHNSON
Assistant Director	W. H. JORDAN
Assistant Director	M. E. RAMSEY
Assistant Director	A. H. SNELL
Assistant Director	GALE YOUNG

U–T—AEC Agricultural Research Laboratory (University of Tennessee, contractor), Oak Ridge, Tenn.

Project Leader	Dr. JOHN A. EWING
Laboratory Director	Dr. N. S. HALL

Sandia Laboratory (Sandia Corp., contractor) Sandia Base Albuquerque, N. Mex.

President	S. P. SCHWARTZ
Vice President, Weapons Programs	R. W. HENDERSON
Vice President, Research	G. C. DACEY
Vice President, Personnel	R. B. POWELL
Vice President, Administration	C. W. CAMPBELL
Vice Presidents, Development	E. H. DRAPER
	G. A. FOWLER
Vice President, Engineering for Manufacture	R. A. BICE

Savannah River Laboratory (E. I. du Pont de Nemours & Co., contractor), Aiken, S.C.

Director	W. P. OVERBECK
Assistant Director	J. W. CROACH, Jr.
Section Director—Physics Sections	G. DESSAUER
Section Director—Pile Engineering & Materials Section.	A. A. JOHNSON
Section Director—Separations & Services Section.	J. W. MORRIS

University of California at Los Angeles, Laboratory of Nuclear Medicine and Radiation (University of California, contractor), Los Angeles, Calif.

Director	Dr. JOSEPH F. ROSS
Assistant Director	T. G. HENNESSY
Project Manager	H. B. THOMPSON

University of California Medical Center, Radiological Laboratory (University of California, contractor), San Francisco, Calif.

Director	Dr. ROBERT S. STONE
Associate Director	Dr. GAIL D. ADAMS

University of California E. O. Lawrence Radiation Laboratory (University of California, contractor), Berkeley, Calif.

Director	Dr. EDWIN M. MCMILLAN
Associate Director and Director, Livermore Laboratory.	Dr. JOHN S. FOSTER, Jr.
Associate Director and Director, Donner Laboratory	Dr. JOHN H. LAWRENCE
Associate Director	Dr. ISADORE PERLMAN
Associate Director	Dr. EDWARD TELLER
Associate Director	Dr. ROBERT L. THORNTON
Associate Director	Dr. HAROLD A. FIDLER
Director, Chemical Bio-Dynamics Laboratory	Dr. MELVIN CALVIN
Director, Inorganic Materials Laboratory	Dr. LEO BREWER
Business Manager and Managing Engineer	WALLACE B. REYNOLDS

Donner Laboratory:	
Assistant Director	Dr. JAMES L. BORN
Assistant Director	Dr. HARDIN B. JONES
Livermore, Associate Directors:	
Chemistry & Acting Associate Director for Testing.	Dr. ROGER E. BATZEL
Plowshare Division Leader	Dr. GARY H. HIGGINS
Sherwood	Dr. CHESTER M. VAN ATTA
Support	DUANE C. SEWELL
Pluto	Dr. THEODORE C. MERKLE
Nuclear Design	Dr. MICHAEL M. MAY
Military Applications	A. CARL HAUSSMAN

University of Rochester Atomic Energy Project (University of Rochester, contractor), Rochester, N.Y.

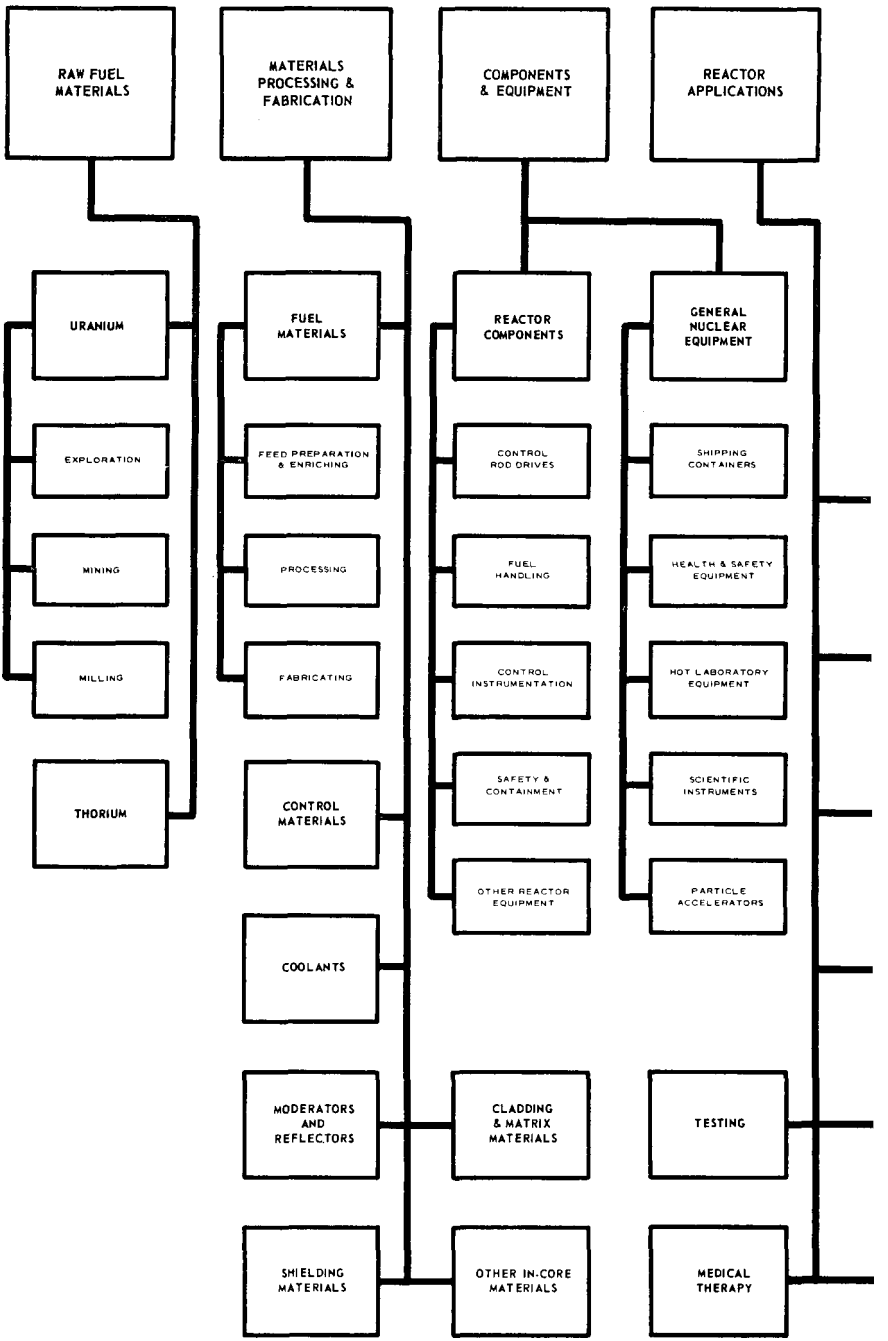
Director	Dr. HENRY A. BLAIR
Business Manager	C. S. THOMPSON

Nevada Test Site, Las Vegas, Nev.

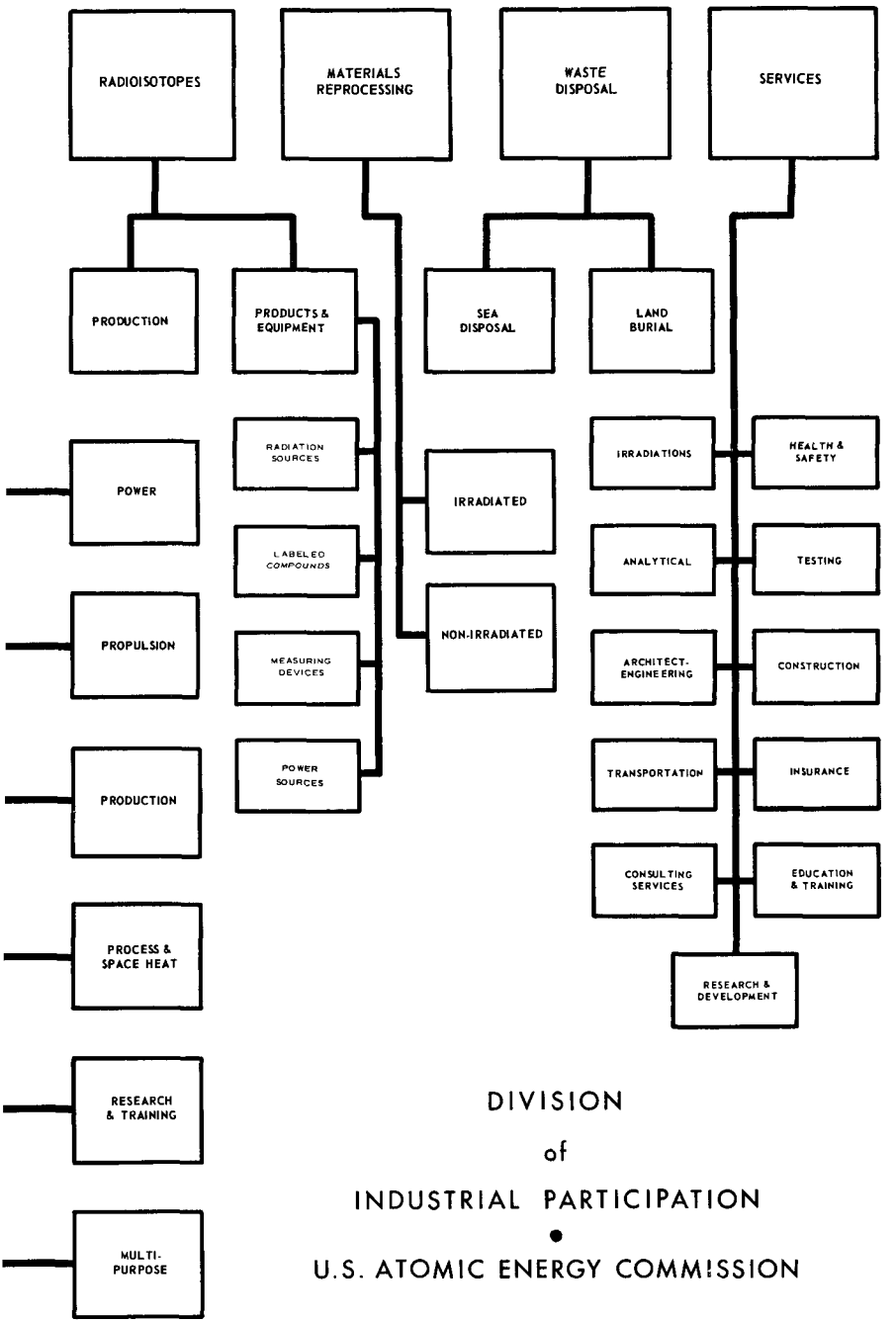
APPENDIX 4

Industries Categories

THE ATOMIC


RAW FUEL MATERIALS
MATERIALS PROCESSING & FABRICATION
COMPONENTS & EQUIPMENT
REACTOR APPLICATIONS
URANIUM
EXPLORATION
MINING
MILLING
THORIUM
FUEL MATERIALS
FEED PREPARATION & ENRICHING
PROCESSING
FABRICATING
CONTROL MATERIALS
COOLANTS
MODERATORS AND REFLECTORS
SHIELDING MATERIALS
REACTOR COMPONENTS
CONTROL ROD DRIVES
FUEL HANDLING
CONTROL INSTRUMENTATION
SAFETY & CONTAINMENT
OTHER REACTOR EQUIPMENT
CLADDING & MATRIX MATERIALS
OTHER IN-CORE MATERIALS
GENERAL NUCLEAR EQUIPMENT
SHIPPING CONTAINERS
HEALTH & SAFETY EQUIPMENT
HOT LABORATORY EQUIPMENT
SCIENTIFIC INSTRUMENTS
PARTICLE ACCELERATORS
TESTING
MEDICAL THERAPY

ENERGY INDUSTRY



DIVISION

of

INDUSTRIAL PARTICIPATION

•

U.S. ATOMIC ENERGY COMMISSION

I - RAW FUEL MATERIALS

A. Uronium
1. Exploration
2. Mining
(Uranium ore)
3. Milling
(U_3O_8)

B. Thorium

II - MATERIALS PROCESSING AND FABRICATION

A. Fuel Materials
1. Feed Preparation & Enriching
a. Uranium Hexaflouride
(1) Conversion
(2) Enriching
(a) Depleted
(b) Enriched
2. Processing (includes Oxides, Compounds, Metals)
a. Depleted Uranium
b. Normal Uranium
c. Enriched Uranium - 5% or less U-235
d. Enriched Uranium - more than 5% U-235
e. Thorium
f. Plutonium
g. U-233
3. Fabricating (includes fission foils and sub-critical and critical fuels)
a. Reactor Fuel Elements and Fueled Control Rods (including sub-assemblies and complete cores)
b. Shapes for non-nuclear uses of depleted uranium.

B. Control Materials
1. Enriching
a. Boron-10
b. Lithium-6
2. Processing
a. Boron
b. Cadmium
c. Hafnium
d. Silver-Cadmium-Indium
e. Rare Earths
3. Fabricating
a. Metal shapes
b. Non-fueled control rods (excluding those shipped as part of complete cores)

C. Coolants
1. Production
a. Heavy water
b. Lithium-7
2. Processing
a. Gases
b. Heavy Water
c. Light Water
d. Liquid Metals
e. Organics

D. Moderators and Reflectors
1. Processing
a. Beryllium
b. Graphite
c. Heavy Water
d. Light Water
e. Organics
2. Fabricating
a. Beryllium
b. Graphite

E. Cladding & Matrix Materials
1. Processing
a. Beryllium
b. Graphite
c. Aluminum
d. Stainless Steel
e. Zirconium & Zircaloy
f. Niobium
g. Molybdenum
2. Fabricating
a. Metal shapes

F. Shielding Materials
1. Fabricating
a. Boron
b. Concrete
c. Lead
d. Carbon Steel
e. Uranium
f. Light Water

G. Other In-Core Materials
1. Fabricating
a. Metal shapes and supports not included elsewhere
b. Piping and tubing

III - COMPONENTS & EQUIPMENT

A. Reactor Components
1. Control Rod Drive Mechanisms and Components
2. Fuel Handling Equipment
3. Instrumentation for Reactor Control
a. Reactor power control instruments
b. Reactor coolant instruments
c. Reactor switchboards and consoles
4. Safety and Containment
a. Vapor suppression systems
b. Containment spheres and shells
5. Other Reactor Equipment
a. Primary Vessels and Tanks
b. Heat Exchangers and Condensers
c. Pressurizers, Components, and Auxiliary Equipment
d. Pumps
e. Valves

B. General Nuclear Equipment
1. Shipping Containers
a. Radioisotopes
b. Irradiated fuel
c. Waste products
2. Health and Safety
a. Nuclear monitoring instruments: area and personnel
(1) Portable
(2) Fixed
(3) Hand and foot counters
b. Nuclear monitoring instruments: environmental
(Gas, liquid and particulate)
c. Dosimeters and accessories
d. Whole body counting equipment
e. Protective clothing
f. Emergency monitoring equipment
g. Decontamination equipment
h. High efficiency filters
i. Film badges
j. Packaged disposal systems
3. Hot Laboratory Type Equipment
a. Shielding windows
b. Remote control manipulators
c. Periscopes and borescopes
d. Laboratory hoods
e. Glove boxes
4. Scientific Instruments (excluding instrument systems for reactor control)
a. Scalers
b. Analyzers
c. Count rate meters
d. Amplifiers
e. Miscellaneous nuclear instruments and accessories (excluding radiation sources and film badges)
5. Particle accelerators

LISTING TO ACCOMPANY CHART OF THE ATOMIC ENERGY INDUSTRY

DIVISION OF INDUSTRIAL PARTICIPATION
USAEC MARCH 1962

IV - REACTOR APPLICATIONS

A. Power
   1. Central station (electric power)
   2. Space auxiliary power
   3. Packaged power plants

B. Propulsion
   1. Space
   2. Other

C. Production
   1. SNM
   2. Isotopes

D. Process & Space Heat
   1. Low Temperature
   2. Intermediate Temperature (an "intermediate temperature" reactor system may be considered one which produces useable saturated steam at 200 psi or above but not higher than 600 psi)
   3. High Temperature

E. Testing

F. Research & Training (including criticals and sub-criticals)

G. Medical Therapy

H. Multipurpose

V - RADIOISOTOPES

A. Production (including separation)
   1. Fission Products
   2. Reactor Produced
   3. Accelerator Produced

B. Products & Equipment
   1. Radiation Sources
      a. Alpha
      b. Beta
      c. Gamma
      d. Neutron
   2. Nuclear Industrial Instruments
   3. Labeled Compounds
   4. Power Sources
      a. For space applications
      b. For other applications

VI - MATERIAL REPROCESSING

A. Irradiated
   1. Uranium
      a. High-enriched
      b. Low-enriched
   2. Plutonium
   3. Thorium
   4. Uranium-thorium mixtures

B. Non-irradiated
   1. Uranium (all chemical forms)
      a. Enriched
      b. Normal
      c. Depleted
      d. U-233
   2. Thorium (all chemical forms)
   3. Plutonium (all chemical forms)
   4. Uranium-thorium mixtures
   5. Precious metals

VII - WASTE DISPOSAL (including storage and handling)

A. Sea Disposal

B. Land Burial

VIII - SERVICES

A. Irradiations
   1. Neutron
   2. Gamma

B. Health & Safety
   1. Environmental monitoring
   2. Film badge service
   3. Calibration and maintenance
   4. Bio-assay
   5. Laundering and cleaning

C. Analytical (other than for health purposes)

D. Testing
   1. Radiographic
   2. Non-destructive

E. Architect-Engineering

F. Construction

G. Transportation

H. Insurance

I. Consulting Services

J. Research & Development

K. Education & Training

APPENDIX 5

Reactors Under Active Design or Construction June 30, 1961, and June 30, 1962

Civilian Power Prototypes and Experiments

Number of Projects for Quarter Ended		
6/30/1961	*6/30/1962*	
1	1	CVTR (Carolinas-Virginia Tube Reactor)
3	2	Enrico Fermi—Power Reactor Development Co.
3	3	Hallam—Consumers Public Power District of Nebraska
4	4	Pathfinder—Northern States Power Co.
5	5	City of Piqua
6	6	Elk River—Rural Cooperative Power Association
7	7	Humboldt Bay—Pacific Gas and Electric Co.
8	8	Indian Point—Consolidated Edison Co.
9	9	EBR–2
10	10	EGCR (Experimental Gas Cooled Reactor)
11	11	Peach Bottom—Philadelphia Electric Co.
12	12	UHTRE (Ultra High Temperature Reactor Experiment)
13	—	LAMPRE–1
14	13	EBWR Modifications
15	14	PWR Modifications
16	15	Saxton Nuclear Reactor Project
17	16	EOCR (Experimental Organic Cooled Reactor)
18	17	BONUS—Puerto Rico Water Resources Authority
19	18	Big Rock Point—Consumers Power Co.
20	19	BORAX–5 (Modification of BORAX–4)
21	20	EBOR (Experimental Beryllium Oxide Reactor)
22	21	MSRE (Molten Salt Reactor Experiment)
23	22	Vallecitos Experimental Superheat Reactor
24	23	LaCrosse Boiling Water Reactor
—	24	LCRE (Lithium Cooled Reactor Experiment)

Civilian Testing

1	1	Plum Brook—National Aeronautics and Space Agency
2	2	JANUS (Biological Research Reactor—ANL)
3	3	HWCTR—Heavy Water Components Test Reactor
3	—	PRTR—Plutonium Recycle Test Reactor
5	4	SPERT–4
6	5	ATR (Advanced Test Reactor)
7	6	Fast Burst Reactor (Health Physics)

Civilian Research and Teaching

1	1	Brookhaven High Flux Beam Research Reactor
2	—	Juggernaut (ANL)
3	—	Texas A&M Research Reactor
4	—	University of Kansas Research Reactor
5	2	Walter Reed Medical Center
6	—	Washington State University Research Reactor
7	3	Georgia Tech Research Reactor

Number of Projects for Quarter Ended		
6/30/1961	*6/30/1962*	
8	—	Union Carbide Research Reactor (Sterling Forest, N.Y.)
9	—	Cornell TRIGA Reactor
10	—	University of Missouri (School of Mines)
11	—	University of Buffalo
12	4	High Flux Isotope Reactor (ORNL)
13	5	Ames Laboratory Research Reactor
14	6	Purdue University
15	7	NASA Mock-Up Reactor
16	8	University of Missouri
17	9	Northrop Corp. (Space Radiation Laboratory)
18	10	Columbia University
19	11	University of Texas
20	12	NBSR (Bureau of Standards)
—	13	Babcock & Wilcox
—	14	Petrolite
—	15	State of Rhode Island
—	16	Kansas State University
		MERCHANT SHIP PROPULSION
1	—	NS Savannah
		MILITARY PROTOTYPES, EXPERIMENTS, AND FIELD PLANTS
1	—	Destroyer Reactor Prototype (D1G) West Milton, N.Y.
2	1	Mobile Low Power Plant (ML-1) NRTS
3	—	Portable Medium Power Plant (PM-1) Sundance, Wyo.
4	—	Stationary Medium Power Plant (SM-1A) Fort Greeley, Alaska
5	—	Portable Medium Power Plant (PM-3A) McMurdo Sound
6	2	Natural Circulation Test Plant (5SG) NRTS
		MILITARY TESTING AND RESEARCH
1	1	SERF—Sandia Engineering Reactor Facility
2	2	NETR—Nuclear Engineering Test Reactor (USAF—Dayton, Ohio)
3	3	Ordnance Pulsed Experimental Research Assembly (USA)
4	—	SPRF—Sandia Pulsed Reactor Facility
5	—	Diamond Ordnance Fuse Laboratory Radiation Facility (USA)
6	4	National Naval Medical Center
		MATERIALS PRODUCTION
1	1	NPR—New Production Reactor

NOTE: Projects are *added* to this tabulation:

(1) During the calendar quarter in which license applications are received.

(2) For projects under the cooperative demonstration program, during the quarter in which a basis for arrangements is submitted to the JCAE.

(3) For Government projects not subject to licensing and not subject to the submission of a basis for arrangements to the JCAE, during the quarter in which Title I work begins. (However, Government projects are not added prior to a decision to proceed with construction at a specific location even though design work may be under way.)

Projects are *dropped* from this tabulation in the quarter following the calendar quarter in which they first operate at design power.

Modifications to existing projects are included only when a substantial increase in the rated power output will result.

APPENDIX 6

Terms Used in Table on Value of Shipments of Atomic Energy Products

Value of Shipments. The net selling value at the factory or plant of the total shipments of each item listed. This value approximates as nearly as possible the actual amounts received or receivable for shipments made during the year. The reported figures represent values f.o.b. plant after discounts and allowances and do not include freight charges or excise taxes. The value of source and special nuclear material furnished by the Atomic Energy Commission is excluded.

Net Orders Received. Includes (*a*) the sales value of orders accepted during the reporting period for products and services to be delivered at some future date; (*b*) the sales value of orders received during the reporting period for immediate delivery; (*c*) the net sales value of contract change documents which increase or decrease the sales value of the orders to which they are related when the parties concerned are in substantial agreement as to the amount involved. Includes as orders only those orders that are supported by binding legal documents, such as signed contracts, letters of awards, or letters of intent. In the case of letters of intent the full amount of sales value is included if the parties concerned are in substantial agreement on this amount; otherwise, only the funds specifically authorized to be expended are included. Orders canceled during the year are excluded.

Nuclear Reactors. Includes only reactors which are shipped fully assembled from the place of manufacture, such as AGN201.

Primary Vessels and Tanks. Includes vessels and tanks designed to contain reactor fuel elements; also internal shields, nozzles, covers, closures, etc., directly associated with the primary vessel. Does not include outer containment shell.

Control Rod Drive Mechanisms and Components. Includes value of entire control rod drive mechanisms as well as any components thereof. Does not include the value of control rods which are included in *fuel elements and control rods*, below.

Accessory Instrumentation for Reactor Control. Includes all monitoring and control instrumentation directly related to the operation of the reactor control system. Does not include environmental monitoring equipment not connected to the reactor control system which is included in *counting devices*, below.

Fuel Handling Equipment. Includes equipment for loading and unloading reactors. Does not include items such as shielded transfer cases which are included in *shielding*, below.

Complete Reactor Fuel Elements and Control Rods. Shipped for installation in a reactor. Includes complete cores.

Partially Fabricated Reactor Fuel Element Materials and Control Rods Not Shipped Directly for Installation or Use in a Reactor. Includes value of pelletizing. Does not include conversion, which is included in *conversion of enriched uranium*, below.

Core Structurals. Includes such items as barrels, cans, boxes, and plates.

Hot Laboratory Equipment. Includes remote handling equipment, globe boxes, and other specialized hot laboratory equipment. Does not include fuel handling equipment.

Shielding. Includes viewing windows and shielded transfer and shipping devices.

Radiation Survey, Monitoring, and Analytical Counting Devices. Includes health-physics instruments such as film badges and dosimeters, survey meters for prospecting, and specialized components for radiation measurement instruments.

Radiation Sources and Other Radioactive Materials Produced From Purchased Isotopes. Includes all sources and labeled compounds containing radioisotopes, including separated fission products distributed from facilities other than those at which they were produced or separated.

Control and Measuring Devices Containing Radioactive Isotopes. Includes radioactive gauges, gauge systems, radiographic equipment, and similar devices designed to measure physical characteristics by means of radioactivity.

Conversion of Enriched Uranium Metal and Compounds. Includes such services as production of enriched UF_6; conversion to oxides, metals, and compounds; and recovery of enriched uranium from non-irradiated scrap or from irradiated material. Does not include pelletizing and steps in the fabrication of metallic fuel elements beyond a primary metal shape, which are included in *fuel elements*, above.

Commercial Irradiation Service. Includes receipts for irradiation services performed for others in test and research reactors, gamma irradiation facilities, accelerators, etc. Does not include value of isotopes produced.

APPENDIX 7

Nuclear Reactors Built, Being Built, or Planned in the United States as of December 31, 1962

This compilation contains information about facilities built, being built, or planned in the United States as of December 31, 1962, which are capable of sustaining a nuclear chain reaction. Certain projects relating to military and space systems are not listed in detail because of their classified nature.

Information is presented in five parts, each of which is categorized by primary function or purpose. The major parts, namely, civilian, military, production, and export, as well as such categories as power, propulsion, and process heat, are self-explanatory. The major parts of the tabulation follow:

I. Civilian Reactors (Domestic)
II. Military Reactors
III. Production Reactors
IV. Reactors for Export
V. Critical Assembly Facilities

Various classes of reactors within these categories are defined as follows:

Reactor Experiment. A reactor in the research and development program, usually producing less than 10 Mw(t), designed for the limited purpose of testing the technical feasibility of a reactor concept or some unique reactor feature or piece of equipment. A reactor experiment is built with the intention of making changes in fueling structure, associated components, or other components of the reactors. (Part I, Sec. 2A.2) Advanced Reactor System Experiments (Part I, Sec. 2B) involve investigations of promising new concepts that have potential for application in several reactor development programs.

Experimental Reactor. A relatively complete reactor plant designed, engineered, constructed, and operated to provide the technical basis for the design of a large-scale nuclear power plant. Design flexibility permits changes to prove out different aspects of reactor technology. Electricity or power generation may or may not be included as part of the plant. (Part I, Sec. 2A.1)

Prototype Reactor Plant. A nuclear power plant of any size designed, constructed, and operated principally for the purpose of proving out economic and technical aspects of a future commercial nuclear power plant of the same type. The generation of significant quantities of electricity, mechanical power, or process heat is usually a function of such a plant. Prototypes (40 to 50 Mw(e) and larger) for large central-station plants are listed in Part I, Sec. 1A.1. Prototypes (smaller than 40 Mw(e)) for small utility stations are listed in Part I, Sec. 1A.2.

Commercial Reactor Plant. A nuclear facility constructed and operated under a license issued under Section 103 of the Atomic Energy Act of 1954 and capable of producing steam for the generation of electricity, propulsion, and space or process heat applications at costs as low as a nonnuclear plant built at the same site. (No reactors presently in the category.)

General Irradiation Test Reactor. This general-test-reactor category includes only those reactors having (1) a thermal output of 10,000 kw or more; (2) test loops or experimental facilities within, or in proximity to, the core; and (3) the use of nuclear radiation for testing the life or performance of reactor components as its major function. (Part I, Secs. 3A.1 and 3A.2, and Part IV, Sec. 2A)

Other Test Reactors (Special). This category includes reactors which are, in general, an integral part of a test performance, have kinetic or short-duration high-power excursion, or are designed for special testing purposes. (Part I, Sec. 3B, and Part II, Sec. 3A)

Research Reactor. Any reactor whose nuclear radiations are used primarily as a research tool for basic or applied research regardless of operating power level. May include facilities for testing reactor materials. (Part I, Sec. 3C; Part II, Sec. 3B; and Part IV, Sec. 2B)

Teaching Reactor. Any reactor operated for the primary purpose of training in the operation and utilization of reactors and for instruction in reactor theory and performance. Thermal power level is usually limited to 10 kw. (Part I, Sec. 3D, and Part IV, Sec. 2C.)

Critical Facility. A reactor capable of sustaining a nuclear chain reaction and designed to test at extremely low power (a few watts) a critical mass, neutron-flux distribution, and other characteristics of flexible arrangement of nuclear fuel, materials of construction, coolant, and other reactor components. Fluid critical facilities are used to explore the critical masses of various concentrations of solutions in differing geometries. Metal critical assemblies are used to investigate the variations in heterogeneous cores. The tabulation of these facilities in Part V excludes those that have been dismantled.

The abbreviated listings in the principal-contractor column refer to the technical organization assigned primary responsibility for design and/or fabrication of the reactor system. The spelled-out forms for those abbreviations, as well as those for designers, shipbuilders, and facility operators, are given in the table on page 487.

Start-up dates refer to the year of first criticality. Estimated dates for projects not yet in service, based on the best available information, are included. The dates for non-Commission projects are estimates announced by the sponsoring organizations.

Reactors are listed as being *operable* under the following circumstances:

1. Federal Government reactors—when criticality is achieved.
2. Non-Federal Government reactors in the United States—when an operating license is issued by the Commission.
3. Reactors for foreign locations—when criticality is achieved.

Reactors are listed as *being built* under the following circumstances:

1. Federal Government reactors—when ground is broken, components are ordered, or construction contract is awarded.
2. Non-Federal Government reactors in the United States—when the construction permit is issued by the Commission.
3. Reactors for foreign locations—when an application for an export license is received by the Commission or when reliable information is received relating to the fabrication of reactor components.

Reactors are listed as being *planned* under the following circumstances:

1. Federal Government reactors—when public announcement is made or appropriate authorization as a project planned for construction is made by the agency involved.
2. Non-Federal Government reactors in the United States—when license application is received by the Commission or a public announcement that includes principal contractor and reactor type is made.
3. Reactors for foreign locations—when public announcement that includes principal contractor and reactor type is made or when the Commission receives information that a U.S. reactor manufacturer is proceeding with preconstruction design and development on the basis of a letter of intent.

The Statistical Summary below excludes critical facilities. All other categories are summarized. Dismantled reactors in these categories are included since such facilities have made significant contributions to reactor technology.

STATISTICAL SUMMARY

	Operated, later dismantled	Operable	Being built	Planned
I. CIVILIAN REACTORS:				
1. Power-reactor prototypes:				
A.1. Prototypes, large central-station plants	----	6	5	3
A.2. Prototypes, small central-station plants	----	1	3	----
B. Prototypes, maritime propulsion (seagoing)	----	1	----	----
2. Experimental power reactor and reactor experiments:				
A.1. Experimental power reactors (generate electricity)	----	5	2	----
A.2. Power-reactor experiments (token electrical production, if any)	4	4	2	----
B. Advanced reactor system experiments	2	1	4	1
C. Space propulsion experiments (ROVER)	6	----	(*)	(*)
D. Auxiliary power for space (SNAP)	----	1	2	----
3. Test, research, and teaching reactors:				
A.1. General irradiation test (Government owned)	----	3	1	----
A.2. General irradiation test (privately owned)	1	1	----	----
B. Special test	----	10	----	----
C. Research	5	34	9	3
D. Teaching	4	38	2	13
II. MILITARY REACTORS:				
1. Defense power-reactor applications:				
A. Electric-power reactors, remote installations	----	4	----	----
B. Propulsion reactors (naval)	1	41	51	----
2. Developmental power reactors:				
A.1. Electric-power-reactor experiments and prototypes	1	3	----	1
A.2. Special purpose (auxiliary power for space)	1	1	----	3
B.1. Naval propulsion reactor prototypes	1	6	1	----
B.2. Aircraft-propulsion reactor experiments	4	----	----	----
B.3. Missile-propulsion reactor experiments (PLUTO)	1	----	1	----
3. Test and research:				
A. Test	1	4	1	----
B. Research	----	7	----	1
III. PRODUCTION REACTORS:				
1. Materials production	----	13	1	----
2. Process development	----	4	----	----
3. Testing	----	2	----	----
IV. REACTORS FOR EXPORT:				
1. Power reactors:				
A. Central-station electric power	----	2	4	1
B. Propulsion	----	1	----	----
2. Test, research, and teaching reactors:				
A. General irradiation test	----	3	----	1
B. Research	----	22	7	3
C. Teaching	----	15	----	4

*A number of KIWI-B and NRX series reactors are expected to be tested in 1963.

LIST OF CONTRACTORS, DESIGNERS, SHIPBUILDERS, AND FACILITY OPERATORS FOR WHICH ABBREVIATIONS APPEAR IN TABLES

AC	Allis-Chalmers Mfg. Co.
ACF	ACF Industries, Inc. (Absorbed by AC)
AG	Aerojet-General Corp.
AGN	Aerojet-General Nucleonics, a Subsidiary of Aerojet-General Corp.
AI	Atomics International, a Division of North American Aviation, Inc.
Alco	Alco Products, Inc.
AMF	AMF Atomics, Inc., a Division of American Machine & Foundry Co.
ANL	Argonne National Laboratory, operated by the University of Chicago
ANPD	Aircraft Nuclear Propulsion Department, General Electric Co.
ARSS	American Radiator & Standard Sanitary Corp.
BAC	Bendix Aviation Corp.
Bethlehem	Shipbuilding Division, Bethlehem Steel Co.
Blaw-Knox	Blaw-Knox Co.
BNL	Brookhaven National Laboratory, operated by Associated Universities, Inc.
B&R	Burns & Roe, Inc.
B&W	Babcock & Wilcox Co.
CL	Clinton Laboratory of the Manhattan Engineer District
Comb	Combustion Engineering, Inc.
Convair	Convair Division, General Dynamics Corp.
Cook	Nucledyne Co., a Division of Cook Electric Co.
CW	Curtiss-Wright Corp.
Daystrom	Daystrom, Inc.
DOD	Department of Defense
du Pont	E. I. du Pont de Nemours & Co., Inc.
Ebasco	Ebasco Services, Inc.
Elec. Boat	Electric Boat Division, General Dynamics Corp.
Fluor	The Fluor Corporation, Ltd.
FW	Foster Wheeler Corp.
GDC	General Atomic Division, General Dynamics Corp.
GE	General Electric Co.
GM	General Motors Corp.
GNEC	General Nuclear Engineering Corp., Subsidiary of Combustion Engineering, Inc.
HKF	H. K. Ferguson Co.
Hughes	Hughes Aircraft Co.
IC	Internuclear Co.
Ingalls	Ingalls Shipbuilding Corp.
Kaman	Kaman Nuclear, a Division of Kaman Aircraft Corp.
KAPL	Knolls Atomic Power Laboratory, operated by General Electric Co.
KE	Kaiser Engineers, a Division of Henry J. Kaiser Co.
LASL	Los Alamos Scientific Laboratory, operated by the University of California
Lockheed	Lockheed Aircraft Corp.
Mare Island	Mare Island Naval Shipyard

Martin	Martin-Marietta Corp.
Maxon	Maxon Construction Co.
Met. Lab	Metallurgical Laboratory of the Manhattan Engineer District
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
Newport News	Newport News Shipbuilding & Dry Dock Co.
NRL	Naval Research Laboratory
NYSC	New York Shipbuilding Corp.
ORNL	Oak Ridge National Laboratory, operated by Union Carbide Nuclear Co., a Division of Union Carbide Corp.
Portsmouth	Portsmouth Naval Shipyard
PPC	Phillips Petroleum Co.
P&W	Pratt & Whitney Aircraft Division, United Aircraft Corp.
Sandia	Sandia Laboratory, operated by Sandia Corp., a Subsidiary of Western Electric Co.
UCLRL	University of California Lawrence Radiation Laboratory
UNC	United Nuclear Corp., Development Division
West	Westinghouse Electric Corp.

PART I.—CIVILIAN REACTORS (Domestic)

1. Power

A. CENTRAL STATION ELECTRIC

A.1. Large-plant Prototypes

Name and/or owner	Location	Principal nuclear contractor	Type	Power [1]		Start-up
				Plant kw(e) net	Reactor kw(t)	
OPERABLE						
Shippingport Atomic Power Station [2] (AEC and Duquesne Light Co.).	Shippingport, Pa	West	Pressurized water	60,000	231,000	1957
Dresden Nuclear Power Station (Commonwealth Edison Co.).	Morris, Ill	GE	Boiling water	208,000	700,000	1959
Yankee Nuclear Power Station [3] (Yankee Atomic Electric Co.).	Rowe, Mass	West	Pressurized water	161,000	540,000	1960
Indian Point Unit No. 1 [4] (Consolidated Edison Co. of New York, Inc.).	Buchanan, N.Y	B&W	Pressurized water	255,000	585,000	1962
Hallam Nuclear Power Facility, Sheldon Station [3] (AEC and Consumers Public Power District).	Hallam, Nebr	AI	Sodium graphite	75,000	240,000	1962
Big Rock Nuclear Power Plant [3] (Consumers Power Co.)	Big Rock Point, Mich	GE	Boiling water	47,800	157,000	1962
BEING BUILT						
Enrico Fermi Atomic Power Plant [3,5] (Power Reactor Development Co.).	Lagoona Beach, Mich	Owner	Fast breeder	60,900	200,000	1963
Pathfinder Atomic Power Plant [3] (Northern States Power Co.).	Sioux Falls, S. Dak	AC	Boiling water, nuclear superheat.	58,500	188,900	1963
Humboldt Bay Power Plant, Unit No. 3 (Pacific Gas and Electric Co.).	Humboldt Bay, Calif	GE	Boiling water	48,500	165,000	1963
Peach Bottom Atomic Power Station-HTGR [3] (Philadelphia Electric Co.).	Peach Bottom, Pa	GDC	Gas cooled, graphite moderated.	40,000	115,000	1964
La Crosse Boiling Water Reactor [3] (AEC and Dairyland Power Cooperative).	Genoa, Wis	AC	Boiling water	50,000	165,000	1965
PLANNED						
Coast Nuclear Station (Southern California Edison)	Camp Pendleton, Calif	West	Pressurized water	355,000	1,150,000	1966
Bodega Bay Atomic Park (Pacific Gas and Electric Co.)	Bodega Bay, Calif	GE	Boiling water	313,000	1,008,000	1966
Ravenswood Reactor Plant (Consolidated Edison Co. of New York).[6]	Long Island City, N.Y		Pressurized water	1,000,000	2,030,000	1970

See footnotes at end of table.

A.2. Small-plant Prototype

Name and/or owner	Location	Principal nuclear contractor	Type	Power [1]		Start-up
				Plant kw(e) net	Reactor kw(t)	
OPERABLE:						
Elk River Reactor (AEC and Rural Cooperative Power Association).[3,7]	Elk River, Minn.	AC	Boiling water	20,000	58,200	1962
BEING BUILT						
Piqua Nuclear Power Facility (AEC & City of Piqua) [3]	Piqua, Ohio	AI	Organic cooled and moderated.	11,400	45,500	1963
Carolinas-Virginia Tube Reactor [3,8] (Carolinas-Virginia Nuclear Power Associates, Inc.).	Parr, S.C.	West	Pressure tube, heavy water	17,000	56,000	1963
Boiling Reactor Nuclear Superheat Project [3] (AEC and Puerto Rico Water Resources Authority).	Punta Higuera, P.R.	GNEC	Boiling water, integral nuclear superheat.	16,300	50,000	1963

B. PROPULSION (Maritime Seagoing Prototypes)

Name and/or owner	Nuclear designer	Shipbuilder	Type	Shaft maximum horsepower	Power, kw(t)	Start-up
OPERABLE						
Nuclear Ship *Savannah* (AEC and Maritime Administration)	B&W	NYSC	Pressurized water	22,000	69,000	1961

2. Experimental Power Reactors and Reactor Experiments

A. Electric Power

A.1. Experimental Reactors

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power [1]		Start-up	Dismantled
					Plant kw(e) Net	Reactor kw(t)		
Operable								
Experimental Boiling Water Reactor [2]	EBWR	Lemont, Ill.	ANL	Boiling water	4,000	100,000	1956	
Vallecitos Boiling Water Reactor (General Electric Company and Pacific Gas and Electric Co.).	VBWR	Pleasanton, Calif.	GE	Boiling water	5,000	50,000	1957	
Sodium Reactor Experiment (AEC and Southern California Edison Co.).	SRE	Santa Susana, Calif.	AI	Sodium graphite	6,000	20,000	1957	
Saxton Nuclear Experimental Reactor Project (Saxton Nuclear Experimental Corp.)		Saxton, Pa.	West	Pressurized water	3,250	20,000	1962	
Boiling Reactor Experiment No. 5	BORAX-5	NRTS, Idaho	ANL	Boiling water, internal nuclear superheat.	3,500	40,000	1962	
Being Built								
Experimental Breeder Reactor No. 2	EBR-2	NRTS, Idaho	ANL	Fast breeder	16,500	62,500	1963	
Experimental Gas Cooled Reactor (AEC and Tennessee Valley Authority).	EGCR	Oak Ridge, Tenn.	KE-AC	Gas cooled, graphite moderated.	21,900	84,300	1964	

See footnotes at end of table.

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A.2. Reactor Experiments

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power		Start-up	Dismantled
					Plant kw (e) net	Reactor kw (t)		
OPERATED, LATER DISMANTLED								
Boiling Reactor Experiment No. 1	BORAX-1	NRTS, Idaho	ANL	Boiling water	No elec.	1,400	1953	1954
Homogeneous Reactor Experiment No. 1	HRE-1	Oak Ridge, Tenn.	ORNL	Aqueous homogeneous solution (UO_2SO_4).	140	1,000	1952	1954
Boiling Reactor Experiments [10]	BORAX-2,3,4	NRTS, Idaho	ANL	Boiling water	2,400	15,500	1954	1958
Homogeneous Reactor Experiment No. 2	HRE-2	Oak Ridge, Tenn.	ORNL	Aqueous homogeneous solution (UO_2SO_4).	300	5,200	1957	1961
OPERABLE								
Experimental Breeder Reactor No. 1 [11]	EBR-1	NRTS, Idaho	ANL	Fast breeder	150	1,400	1951	
Organic Moderated Reactor Experiment	OMRE	NRTS, Idaho	AI	Organic cooled and moderated.	No elec.	16,000	1957	
Plutonium Recycle Test Reactor	PRTR	Hanford, Wash.	GE	Pressure tube, heavy-water-moderated-and-cooled.	No elec.	70,000	1960	
Heavy Water Components Test Reactor.	HWCTR	Savannah River Plant, Aiken, S.C.	duPont	Pressurized heavy water	No elec.	61,000	1962	
BEING BUILT								
Experimental Organic Cooled Reactor	EOCR	NRTS, Idaho	Fluor-AI	Organic cooled and moderated.	No elec.	40,000	1963	
ESADA Vallecitos Experimental Superheat Reactor (Empire States Atomic Development Associates and General Electric Co.).[12]	EVESR	Pleasanton, Calif.	GE	Light water moderated, superheater.	No elec.	12,500	1963	

B. Advanced Reactor System Experiments

OPERATED, LATER DISMANTLED								
Los Alamos Power Reactor Experiment No. 1.	LAPRE-1	Los Alamos, N. Mex.	LASL	Aqueous homogeneous (phosphoric acid).	No elec.	2,000	1956	1957

Los Alamos Power Reactor Experiment No. 2.	LAPRE-2	Los Alamos, N. Mex.	LASL	Aqueous homogeneous (phosphoric acid).	No elec.	1,000	1959	1959
OPERABLE								
Los Alamos Molten Plutonium Reactor Experiment.	LAMPRE-1	Los Alamos, N. Mex.	LASL	Fast molten plutonium fueled, sodium cooled.	No elec.	1,000	1961	----
BEING BUILT								
Molten Salt Reactor Experiment	MSRE	Oak Ridge, Tenn.	ORNL	Single region graphite moderated.	No elec.	10,000	1964	----
Ultra-High Temperature Reactor Experiment.[13]	UHTREX	Los Alamos, N. Mex.	LASL	Helium cooled	No elec.	3,000	1965	----
Experimental Beryllium Oxide Reactor [14]	EBOR	NRTS, Idaho	GDC	Gas cooled, BeO moderated	No elec.	10,000	1964	----
Lithium Cooled Reactor Experiment [15]	LCRE	NRTS, Idaho	P&W	Liquid metal cooled	No elec.	10,000	1965	----
PLANNED								
Fast Reactor Core Test Facility [16]	FRCTF	Los Alamos, N. Mex.	LASL	Fast molten plutonium fueled, sodium cooled.	No elec.	20,000	1965	----

C. SPACE PROPULSION EXPERIMENTS (ROVER)

Name	Designation	Location	Principal nuclear contractor	Type	Start-up
OPERATED AND TESTED					
Nuclear Rocket Propulsion Experiment	KIWI-A	NRDS, Nev.	LASL	Open cycle, hydrogen gas cooled	1959
Nuclear Rocket Propulsion Experiment	KIWI-A Prime	NRDS, Nev.	LASL	Open cycle, hydrogen gas cooled	1960
Nuclear Rocket Propulsion Experiment	KIWI-A3	NRDS, Nev.	LASL	Open cycle, hydrogen gas cooled	1960
Nuclear Rocket Propulsion Experiment	KIWI-B1A	NRDS, Nev.	LASL	Open cycle, hydrogen gas cooled	1961
Nuclear Rocket Propulsion Experiment	KIWI-B1B	NRDS, Nev.	LASL	Open cycle, liquid hydrogen cooled	1962
Nuclear Rocket Propulsion Experiment	KIWI-B4A	NRDS, Nev.	LASL	Open cycle, liquid hydrogen cooled	1962
BEING BUILT					
Nuclear Rocket Propulsion Experiments	KIWI-B Series	NRDS, Nev.	LASL	Open cycle, liquid hydrogen	1963
PLANNED					
Nuclear Rocket Propulsion Experiments	KIWI-B Series	NRDS, Nev.	LASL	Open cycle, liquid hydrogen	1963
Nuclear Engine Reactor Experiments (NERVA)	NRX Series	NRDS, Nev.	AGN-West		1963

See footnotes at end of table.

D. Auxiliary Power for Space (SNAP)[17]

Name	Designation	Location	Principal nuclear contractor	Type	Power [1]		Start-up
					Plant kw(e) Net	Reactor kw(t)	
Operable							
SNAP 8 Experimental Reactor	S8ER	Santa Susana, Calif.	AI	NaK cooled		600	1962
Being Built							
SNAP 8 Ground Prototype System	S8DS	Santa Susana, Calif.	AI	NaK cooled	30–60	600	1964
SNAP 8 Flight Prototype System	S8FS	Santa Susana, Calif.	AI	NaK cooled	30–60	600	1965

3. Test, Research, and Teaching Reactors

A. General Irradiation Testing

A.1. Government Facilities

Name and/or owner	Designation	Location	Principal nuclear contractor	Operator	Type	Power [1] kw(t)	Start-up
Operable							
Materials Testing Reactor (AEC)[18]	MTR	NRTS, Idaho	ORNL–ANL Blaw-Knox	PPC	Tank	40,000	1952
Engineering Test Reactor (AEC)	ETR	NRTS, Idaho	KE–GE	PPC	Tank	175,000	1957
Plum Brook Reactor Facility (NASA)	NASA–TR	Sandusky, Ohio	NASA		Tank	60,000	1961
Being Built							
Advanced Test Reactor (AEC)	ATR	NRTS, Idaho	Ebasco-B&W	PPC	Tank	250,000	1965

A.2. Private Facilities

OPERATED, LATER DISMANTLED							
Westinghouse Testing Reactor [19]	WTR	Waltz Mill, Pa	Owner	Owner	Tank	60,000	1959
OPERABLE							
General Electric Testing Reactor	GETR	Pleasanton, Calif	Owner	Owner	Tank	33,000	1958

B. Other Testing (Special)

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Power [1] kw(t)	Start-up
OPERABLE						
Bulk Shielding Reactor [20]	BSR-1-BSR-2	Oak Ridge, Tenn	ORNL	Pool	1,000	1950
Special Power Excursion Reactor Test No. 1	SPERT-1	NRTS, Idaho	PPC	Open tank	Transient	1955
Special Power Excursion Reactor Test No. 2	SPERT-2	NRTS, Idaho	PPC	Pressurized water	Transient	1960
Special Power Excursion Reactor Test No. 3	SPERT-3	NRTS, Idaho	PPC	Pressurized water	Transient	1958
Special Power Excursion Reactor Test No. 4	SPERT-4	NRTS, Idaho	PPC	Pool	Transient	1962
Kinetic Experiment on Water Boilers	KEWB	Santa Susana, Calif	AI	Homogeneous	50	1956
Transient Test Reactor Facility	TREAT	NRTS, Idaho	ANL	Graphite	Transient	1959
Fast Source Reactor	AFSR	NRTS, Idaho	ANL	Fast	1	1959
Health Physics Research Reactor	HPRR	Oak Ridge, Tenn	ORNL	Fast burst	1	1962
SNAP Shield Test Experiment		Santa Susana, Calif	AI	Pool	50	1961

See footnotes at end of table.

C. Research

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power [1, 21] kw(t)	Start-up	Dismantled
OPERATED, LATER DISMANTLED							
Los Alamos Water Boiler	HYPO	Los Alamos, N. Mex.	LASL	Homogeneous	5.5	1944	1950
Chicago Pile 1, rebuilt as CP-2 [22] (Manhattan Engineer District–AEC).	CP-1	Chicago, Ill.	Met. Lab.	Graphite	0.2 to 2	1942	1954
Argonne CP-3, rebuilt as CP-3 (Manhattan Engineer District–AEC).	CP-3	Palos Park, Ill.	Met. Lab.	Heavy water	300	1944	1954
Los Alamos Fast Reactor (AEC)	Clementine	Los Alamos, N. Mex.	LASL	Fast, plutonium fuel, mercury cooled.	25	1946	1953
Shield Test Pool Reactor	Susie	NRTS, Idaho	ANPO	Pool	2,000	1959	1962
OPERABLE							
Oak Ridge Graphite Reactor (AEC)	X-10	Oak Ridge, Tenn.	CL	Graphite	3,800	1943	
Los Alamos Water Boiler (AEC)	SUPO	Los Alamos, N. Mex.	LASL	Homogeneous	25	1950	
Brookhaven Research Reactor (AEC)	BGRR	Upton, N.Y.	HKF	Graphite	20,000	1950	
Low Intensity Test Reactor (AEC) [23]	LITR	Oak Ridge, Tenn.	ORNL	Tank	3,000	1950	
North American Aviation Water Boiler Neutron Source (AEC). [24]	AE-6(WBNS)	Santa Susana, Calif.	AI	Homogeneous	50	1952	
Livermore Water Boiler (AEC)	LIWB	Livermore, Calif.	AI	Homogeneous	0.5	1953	
Argonne Research Reactor (AEC)	CP-5	Lemont, Ill.	ANL	Heavy water	5,000	1954	
Pennsylvania State University		University Park, Pa.	Owner	Pool	200	1955	
Armour Research Foundation	ARR	Chicago, Ill.	AI	Homogeneous	75	1956	
Battelle Memorial Institute	BRR	West Jefferson, Ohio	AMF	Pool	2,000	1956	
Omega West Reactor (AEC)	OWR	Los Alamos, N. Mex.	LASL	Tank	5,000	1956	
General Electric Nuclear Test Reactor	NTR	Pleasanton, Calif.	GE	Light water	30	1957	
University of Michigan (Ford Nuclear Reactor)		Ann Arbor, Mich.	B&W	Pool	1,000	1957	
Livermore Pool Type Reactor (AEC)	LPTR	Livermore, Calif.	FW	Tank	2,000	1957	
The Curtiss-Wright Nuclear Research Laboratory of the Pennsylvania State University. [25]		Quehanna, Pa.	Owner	Pool	4,000	1958	
General Dynamics Corp.	TRIGA-Mk I	La Jolla, Calif.	GDC	U-Zr hydride, tank	250	1958	
Brookhaven Neutron Source Reactor (AEC)		Upton, N.Y.	BNL	Tank	100	1958	
Radiation Effects Reactor (USAF—Operated by *Lockheed Aircraft Corp.*) [26]	RER	Dawsonville, Ga.	Lockheed	Pool	10,000	1958	
Massachusetts Institute of Technology	MITR	Cambridge, Mass.	ACF	Heavy water	2,000	1958	

Industrial Reactor Laboratories, Inc. (Operated by Columbia University).		Plainsboro, N.J	AMF	Pool	5,000	1958
Babcock & Wilcox Lynchburg Pool Reactor	LPR	Lynchburg, Va	Owner	Pool	450	1958
Oak Ridge Research Reactor (AEC)	ORR	Oak Ridge, Tenn	ORNL	Tank	30,000	1958
Brookhaven Medical Research Reactor (AEC)	MRR	Upton, N.Y	Daystrom	Tank	5,000	1959
Omaha Veterans Administration Hospital	TRIGA-Mk I	Omaha, Nebr	GDC	U-Zr hydride, tank	10	1959
General Dynamics Corp. TRIGA Pulsing Reactor.[26]	TRIGA-Mk F	La Jolla, Calif	Owner	U-Zr hydride, tank	1,000	1960
University of Virginia		Charlottesville, Va	Owner-B&W	Pool	1,000	1960
Puerto Rico Nuclear Center (AEC)		Mayaguez, P.R	AMF	Pool	1,000	1960
Western New York Nuclear Research Center, Inc.		Buffalo, N.Y	AMF	Pool	1,000	1961
Washington State University		Pullman, Wash	GE	Pool	100	1961
Union Carbide Nuclear Co		Sterling Forest, N.Y	AMF	Pool	5,000	1961
University of Missouri, School of Mines and Metallurgy.		Rolla, Mo	CW	Pool	10	1961
Nuclear Science Center Reactor, Agricultural and Mechanical College of Texas.	NSCR	College Station, Tex	Convair	Pool	100	1961
Sandia Pulsed Reactor	SPR	Sandia Base, N. Mex	Sandia	Prompt burst		1961
Sandia Engineering Reactor	SER	Sandia Base, N. Mex	Sandia	Tank	5,000	1962
Argonne Low Power Research Reactor (AEC) [27]	Juggernaut	Lemont, Ill	ANL	Graphite/water	250	1962
Rhode Island Atomic Energy Commission		Ft. Kearny, R.I	GE	Pool	3,000	1962
BEING BUILT						
Brookhaven High Flux Beam Research Reactor (AEC).	HFBR	Upton, N.Y	BNL	Heavy water	40,000	1964
Ames Laboratory Research Reactor (AEC)	ALRR	Ames, Iowa	AMF	Heavy water	5,000	1964
Biological Research Reactor (AEC)	JANUS	Lemont, Ill	ANL	Tank	200	1963
Georgia Institute of Technology	GTRR	Atlanta, Ga	GNEC	Heavy water	1,000	1963
NASA Mock-up Reactor	MUR	Sandusky, Ohio	Lockheed	Light water, pool	100	1963
Northrop Corp. (Space Radiation Laboratory)	TRIGA-Mk F	Hawthorne, Calif	GDC	U-Zr hydride, tank	100	1963
High Flux Isotope Reactor (AEC)	HFIR	Oak Ridge, Tenn	ORNL	Pool flux trap	100,000	1965
National Bureau of Standards	NBSR	Gaithersburg, Md	NBS-B&R	Heavy water	10,000	1965
PLANNED						
University of Missouri		Columbia, Mo	Owner-IC	Tank	10,000	1964
Petrolite Corp. Irradiation Reactor		Webster Groves, Mo	IC	Pool	10	1963
Babcock & Wilcox Nuclear Development Center Test Reactor.	BAWTR	Lynchburg, Va	Owner	Pool	6,000	1963

See footnotes at end of table.

D. Teaching

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power [1, 21] kw(t)	Start-up	Dismantled
OPERATED, LATER DISMANTLED							
Atomics International	L-47	Canoga Park, Calif.	AI	Homogeneous	Negligible	1957	1958
American Radiator & Standard Sanitary Corp.[29]	UTR-1	Mountain View, Calif.	ARSS	Graphite/water	Negligible	1958	1960
General Dynamics Corp. (World Agricultural Fair-U.S. Exhibit Reactor).[30]		San Diego, Calif.	GDC	TRIGA-Mk II	50	1960	1960
National Naval Medical Center (USN)	AGN-201M-105	Bethesda, Md.	AGN	Homog. solid	Negligible	1957	1962
OPERABLE							
North Carolina State College[31] (Raleigh Research Reactor).	RRR	Raleigh, N.C.	Owner	Homogeneous	0.5	1957	
Argonne Nuclear Assembly for University Training (AEC).	Argonaut (CP-11).	Lemont, Ill.	ANL	Graphite/water	10	1957	
Catholic University of America	AGN-201-101	Washington, D.C.	AGN	Homog. solid	Negligible	1957	
Oklahoma State University of Agriculture and Applied Science.	AGN-201-102	Stillwater, Okla.	AGN	Homog. solid	Negligible	1957	
Aerojet-General Nucleonics	AGN-201P-103	San Ramon, Calif.	AGN	Homog. solid	Negligible	1957	
University of Akron	AGN-201-104	Akron, Ohio	AGN	Homog. solid	Negligible	1957	
Agricultural and Mechanical College of Texas	AGN-201-106	College Station, Tex.	AGN	Homog. solid	Negligible	1957	
University of Utah	AGN-201-107	Salt Lake City, Utah	AGN	Homog. solid	Negligible	1957	
Argonne National Laboratory (AEC)	AGN-201-108	Lemont, Ill.	AGN	Homog. solid	Negligible	1957	
Colorado State University	AGN-201-109	Ft. Collins, Colo.	AGN	Homog. solid	Negligible	1957	
University of California	AGN-201-112	Berkeley, Calif.	AGN	Homog. solid	Negligible	1957	
University of Delaware	AGN-201-113	Newark, Del.	AGN	Homog. solid	Negligible	1958	
Oregon State University	AGN-201-114	Corvallis, Oreg.	AGN	Homog. solid	Negligible	1958	
Atomics International	L-77	Canoga Park, Calif.	AI	Homogeneous	Negligible	1958	
Pawling Research Reactor	PRR	Pawling, N.Y.	UNC	Heavy water	Negligible	1958	
William Marsh Rice University	AGN-211-101	Houston, Tex.	AGN	Homog. solid, pool	Negligible	1959	
University of Oklahoma	AGN-211-102	Norman, Okla.	AGN	Homog. solid, pool	Negligible	1958	
West Virginia University, College of Engineering	AGN-211-103	Morgantown, W. Va.	AGN	Homog. solid, pool	Negligible	1959	
University of Arizona	TRIGA	Tucson, Ariz.	GDC	U-Zr hydride, tank	10	1958	
University of Wyoming	L-77	Laramie, Wyo.	AI	Homogeneous	Negligible	1959	
University of Florida	UFTR	Gainesville, Fla.	GNEC	Graphite/water	10	1959	
Puerto Rico Nuclear Center (AEC)	L-77	Mayaguez, P.R.	AI	Homogeneous	Negligible	1959	

Iowa State University	UTR-10	Ames, Iowa	ARSS	Graphite/water	10	1959	
Leland Stanford University		Palo Alto, Calif	GE	Pool	10	1959	
Worcester Polytechnic Institute		Worcester, Mass	GE	Pool	1	1959	
Virginia Polytechnic Institute	UTR-10	Blacksburg, Va	ARSS	Graphite/water	10	1959	
North Carolina State College		Raleigh, N.C	Cook	Graphite/water	10	1960	
University of Illinois	TRIGA-Mk II	Urbana - Champaign, Ill.	GDC	U-Zr hydride, tank	100	1960	
University of Maryland	UMNE-1	College Park, Md	AC	Tank	10	1960	
University of California at Los Angeles, College of Engineering.	Educator	Los Angeles, Calif	AMF	Graphite/water	10	1960	
University of Wisconsin		Madison, Wis	GE	Pool	10	1960	
Ohio State University		Columbus, Ohio	Lockheed	Pool	10	1960	
University of Washington	Educator	Seattle, Wash	AMF	Graphite/water	10	1960	
AEC South American Exhibits Program Reactor.[32]			Lockheed	Pool	10	1960	
University of Kansas	Model 4180	Lawrence, Kans	BAC	Pool	10	1961	
Cornell University	TRIGA-Mk II	Ithaca, N.Y	GDC	U-Zr hydride	100	1962	
UTR Test Reactor (American Radiator and Standard Sanitary Corp.).		Mountain View, Calif	Owner	Graphite/water	Negligible	1961	
Kansas State University	TRIGA-Mk II	Manhattan, Kans	GDC	U-Zr hydride, tank	10	1962	
Purdue University		West Lafayette, Ind	Lockheed	Pool	10	1962	
BEING BUILT							
Texas Technological College		Lubbock, Tex	Convair	Pool	10	1963	
University of Texas	TRIGA-Mk I	Austin, Tex	GDC	U-Zr hydride, tank	10	1963	
PLANNED							
Columbia University	TRIGA-Mk II	New York City	GDC	U-Zr hydride, tank	250	1964	
Aerojet-General Nucleonics[33] (5 reactors)	AGN-201 (126-130).	San Ramon, Calif	AGN	Homog. solid	Negligible		
Aerojet-General Nucleonics (5 reactors)[33]	AGN-211	San Ramon, Calif	AGN	Homog. solid, pool	Negligible		
Manhattan College Corp		Riverdale, New York City.	AMF	Pool	Negligible	1964	
University of Nevada	L-77	Reno, Nev	AI	Homogeneous	Negligible		

See footnotes at end of table.

PART II.—MILITARY REACTORS

1. DEFENSE POWER APPLICATIONS

A. ELECTRICAL-POWER GENERATION FOR REMOTE INSTALLATION

Name (all owned by DOD)	Designation [34]	Location	Principal nuclear contractor	Type	Power [1] net kw(e)	Start-up
OPERABLE						
Stationary Medium Power Plant No. 1	SM-1	Ft. Belvoir, Va	Alco	Pressurized water	1,855	1957
Portable Medium Power Plant No. 2A [35]	PM-2A	Camp Century, Greenland	Alco	Pressurized water	1,500	1960
Stationary Medium Power Plant No. 1A [36]	SM-1A	Fort Greely, Alaska	Alco	Pressurized water	1,640	1962
Portable Medium Power Plant No. 3A	PM-3A	McMurdo Sound, Antarctica.	Martin	Pressurized water	1,500	1962
PLANNED						
Mobile High Power Plant No. 1A	MH1A	Liberty Ship *Walter H. Perry.*	Martin	Pressurized water	10,000	1965

B. PROPULSION (NAVAL)

Name (all owned by U.S. Navy)	Designation	Nuclear designer	Shipbuilder	Type [37]	Start-up	Dismantled
OPERATED, LATER DISMANTLED						
Seawolf S2G Sodium Reactor		GE		Sodium	1956	1959
OPERABLE						
USS Nautilus	SSN571	West	Elec. Boat	S2W	1954	
USS Seawolf [38]	SSN575	West	Elec. Boat	S2Wa	1960	
USS Skate	SSN578	West	Elec. Boat	S3W	1957	
USS Swordfish	SSN579	West	Portsmouth	S4W	1958	
USS Sargo	SSN583	West	Mare Island	S3W	1958	
USS Seadragon	SSN584	West	Portsmouth	S4W	1959	
USS Skipjack	SSN585	West	Elec. Boat	S5W	1958	
USS Triton (2 reactors)	SSN586	GE	Elec. Boat	S4G	1959	
USS Halibut	SSG(N)587	West	Mare Island	S3W	1959	
USS Scamp	SSN588	West	Mare Island	S5W	1961	

USS Scorpion	SSN589	West	Elec. Boat	S5W	1960	
USS Sculpin	SSN590	West	Ingalls	S5W	1961	
USS Shark	SSN591	West	Newport News	S5W	1960	
USS Snook	SSN592	West	Ingalls	S5W	1961	
USS Thresher	SSN593	West	Portsmouth	S5W	1961	
USS Permit	SSN594	West	Mare Island	S5W	1962	
USS Plunger	SSN595	West	Mare Island	S5W	1962	
USS Tullibee	SSN597	Comb	Elec. Boat	S2C	1960	
USS George Washington	SSB(N)598	West	Elec. Boat	S5W	1959	
USS Patrick Henry	SSB(N)599	West	Elec. Boat	S5W	1960	
USS Theodore Roosevelt	SSB(N)600	West	Mare Island	S5W	1960	
USS Robert E. Lee	SSB(N)601	West	Newport News	S5W	1960	
USS Abraham Lincoln	SSB(N)602	West	Portsmouth	S5W	1960	
USS Ethan Allen	SSB(N)608	West	Elec. Boat	S5W	1961	
USS Sam Houston	SSB(N)609	West	Newport News	S5W	1961	
USS Thomas A. Edison	SSB(N)610	West	Elec. Boat	S5W	1961	
USS John Marshall	SSB(N)611	West	Newport News	S5W	1962	
USS Thomas Jefferson	SSB(N)618	West	Newport News	S5W	1962	
USS Long Beach (2 reactors)	CG(N)9	West	Bethlehem	C1W	1961	
USS Enterprise (8 reactors)	CVA(N)65	West	Newport News	A2W	1960	
USS Bainbridge (2 reactors)	DLG(N)25	GE	Bethlehem	D2G	1962	
BEING BUILT						
Submarine Barb	SSN596	West	Ingalls	S5W		
Submarine Pollack	SSN603	West	NYSC	S5W		
Submarine Haddo	SSN604	West	NYSC	S5W		
Submarine Jack	SSN605	West	Portsmouth	S5W		
Submarine Tinosa	SSN606	West	Portsmouth	S5W		
Submarine Dace	SSN607	West	Ingalls	S5W		
Submarine Guardfish	SSN612	West	NYSC	S5W		
Submarine Flasher	SSN613	West	Elec. Boat	S5W		
Submarine Greenling	SSN614	West	Elec. Boat	S5W		
Submarine Gato	SSN615	West	Elec. Boat	S5W		
Submarine Lafayette	SSB(N)616	West	Elec. Boat	S5W		
Submarine Alexander Hamilton	SSB(N)617	West	Elec. Boat	S5W		
Submarine Andrew Jackson	SSB(N)619	West	Mare Island	S5W		
Submarine John Adams	SSB(N)620	West	Portsmouth	S5W		
Submarine Haddock	SSN621	West	Ingalls	S5W		
Submarine James Monroe	SSB(N)622	West	Newport News	S5W		

See footnotes at end of table.

B. Propusion (Naval)—Continued

Name (all owned by U.S. Navy)	Designation	Nuclear designer	Shipbuilder	Type [87]	Start-up	Dismantled
Being Built—Continued						
Submarine Nathan Hale	SSB(N)623	West	Elec. Boat	S5W		
Submarine Woodrow Wilson	SSB(N)624	West	Mare Island	S5W		
Submarine Henry Clay	SSB(N)625	West	Newport News	S5W		
Submarine Daniel Webster	SSB(N)626	West	Elec. Boat	S5W		
Submarine James Madison	SSB(N)627	West	Newport News	S5W		
Submarine Tecumseh	SSB(N)628	West	Elec. Boat	S5W		
Submarine Daniel Boone	SSB(N)629	West	Mare Island	S5W		
Submarine John Calhoun	SSB(N)630	West	Newport News	S5W		
Submarine Ulysses S. Grant	SSB(N)631	West	Elec. Boat	S5W		
Submarine von Steuben	SSB(N)632	West	Newport News	S5W		
Submarine Casimir Pulaski	SSB(N)633	West	Elec. Boat	S5W		
Submarine Stonewall Jackson	SSB(N)634	West	Mare Island	S5W		
Submarine Sam Rayburn	SSB(N)635	West	Newport News	S5W		
Submarine Nathanael Greene	SSB(N)636	West	Portsmouth	S5W		
Submarine	SSN637	West	Elec. Boat	S5W		
Submarine Whale	SSB638	West	Bethlehem	S5W		
Submarine Tautog	SSN639	West	Ingalls	S5W		
Submarine	SSB(N)640	West	Elec. Boat	S5W		
Submarine	SSB(N)641	West	Newport News	S5W		
Submarine	SSB(N)642	West	Mare Island	S5W		
Submarine	SSB(N)643	West	Elec. Boat	S5W		
Submarine	SSB(N)644	West	Newport News	S5W		
Submarine	SSB(N)645	West	Elec. Boat	S5W		
Submarine	SS(N)646	West	Portsmouth	S5W		
Submarine	SS(N)647	West	NYSC	S5W		
Submarine	SS(N)648	West	Ingalls	S5W		
Submarine	SS(N)649	West	Bethlehem	S5W		
Submarine	SS(N)650	West		S5W		
Submarine	SS(N)651	West		S5W		
Submarine	SS(N)652	West		S5W		
Submarine	SS(N)653	West		S5W		
Guided Missile Destroyer Leader (Frigate) (2 reactors)	DLG(N)35	GE		D2G		
Guided Missile Destroyer Leader (Frigate) (2 reactors)	DLG(N)36	GE		D2G		

2. Development Power

A. Electric Power Experiments and Prototypes

A.1. Power for Remote Installations

Name (all owned by AEC except as noted)	Designation [31]	Location	Principal nuclear contractor	Type	Power [1]		Startup	Dismantled
					Plant kw(e) Net	Reactor kw(t)		
Operated, Later Dismantled								
Stationary Low Power Plant No. 1	SL-1	NRTS, Idaho	ANL	Boiling water	200	3,000	1958	1961
Operable								
Gas Cooled Reactor Experiment [39]	GCRE-1	NRTS, Idaho	AGN	Gas cooled, light water moderated.	No elec	2,200	1960	
Mobile Low Power Plant No. 1	ML-1	NRTS, Idaho	AGN	Gas cooled, light water moderated.	330	3,300	1961	
Portable Medium Power Plant No. 1 (USAF-AEC).[40]	PM-1	Sundance, Wyo	Martin	Pressurized water	1,000	9,370	1962	
Planned								
Military Compact Reactor	MCR	NRTS, Idaho	GM	Liquid metal cooled	2,000 to 3,000			

A.2. Special Purpose (Auxiliary Power for Space)[17]

Name	Designation	Location	Principal nuclear contractor	Type	Power [1]		Startup	Dismantled
					Plant kw(e) Net	Reactor kw(t)		
Operated, Later Dismantled								
SNAP 2 Experimental Reactor	SER	Santa Susana, Calif	AI	NaK cooled		50	1959	1961
Operable								
SNAP 2 Developmental System No. 1	S2DS	Santa Susana, Calif	AI	NaK cooled	3	50	1961	
Planned								
SNAP 2 Flight System No. 1	S2FS-I	Santa Susana, Calif	AI	NaK cooled	3	55	1964	
SNAP 10 Flight System No. 1	S10FS-I	Santa Susana, Calif	AI	NaK cooled	0.5	30	1964	
SNAP 50 Prototype System	S50DR-1	NRTS, Idaho	P&W	Li cooled		8,000–10,000	1966	

See footnotes at end of table.

B. Propulsion Experiments and Prototypes

B.1. Naval

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power [1] kw(t)	Start-up	Dismantled
Operated, Later Dismantled							
Submarine Intermediate Reactor Mark A	S1G	West Milton, N.Y.	GE	Sodium		1955	1957
Operable							
S1W Reactor Facility	S1W	NRTS, Idaho	West	Pressurized water		1953	
Large Ship Reactor Prototype (2 reactors)	A1W	NRTS, Idaho	West	Pressurized water		1958	
Submarine Advanced Reactor Prototype	S3G	West Milton, N.Y.	GE	Pressurized water		1958	
Small Submarine Reactor Prototype	S1C	Windsor, Conn.	Comb.	Pressurized water		1959	
Destroyer Reactor Prototype	D1G	West Milton, N.Y.	GE	Pressurized water		1962	
Being Built							
Natural Circulation Test Plant	S5G	NRTS, Idaho	GE	Pressurized water		1964	

B.2. Aircraft [41]

Operated, Later Dismantled							
Aircraft Reactor Experiment	ARE	Oak Ridge, Tenn.	ORNL	Molten salt		1954	1954
Heat Transfer Reactor Experiment No. 1	HTRE-1	NRTS, Idaho	ANPD	Air cooled	20,000	1956	1957
Heat Transfer Reactor Experiment No. 2	HTRE-2	NRTS, Idaho	ANPD	Air cooled	14,000	1957	
Heat Transfer Reactor Experiment No. 3	HTRE-3	NRTS, Idaho	ANPD	Air cooled	32,000	1958	

B.3. Missile (Project PLUTO)

Operated, Later Dismantled							
Experimental Propulsion Test Reactor	Tory-IIA	NTS, Nev.	UCLRL	Air cooled	160,000	1960	1961
Being Built							
Experimental Propulsion Test Reactor	Tory-IIC	NTS, Nev.	UCLRL	Air cooled		1963	

3. Test and Research

A. Test

Operated, Later Dismantled							
Tower Shielding Reactor No. 1	TSR-1	Oak Ridge, Tenn.	ORNL	Tank	500	1954	1958
Operable							
Ground Test Reactor (USAF) [41]	GTR	Ft. Worth, Tex.	Convair	Pool	3,000	1953	
Aircraft Shield Test Reactor (USAF) [41]	ASTR	Ft. Worth, Tex.	Convair	Light water	3,000	1954	
Tower Shielding Reactor No. 2	TSR-2	Oak Ridge, Tenn.	ORNL	Light water	100	1960	
Shield Test Experiment	STE	Santa Susana, Calif.	AI	Pool	50	1961	
Being Built							
Nuclear Engineering Test Reactor (USAF) [42]	NETR	Dayton, Ohio	Maxon-AC	Pool	10,000	1963	

B. Research

Operable							
Thermal Test Reactor No. 1	TTR-1	Schenectady, N.Y.	KAPL	Graphite	10	1951	
Naval Research Reactor (USN)	NRR	Washington, D.C.	NRL	Pool	1,000	1956	
U.S. Naval Post Graduate School (USN)	AGN-201-100	Monterey, Calif.	AGN	Homog. solid	Negligible	1956	
Horace Hardy Lester Reactor for Materials Research (Watertown Arsenal, USA).		Watertown, Mass.	Owner	Pool	1,000	1961	
Diamond Ordnance Fuse Laboratory Radiation Facility (USA).[26]	TRIGA-Mk-F (DORF).	Washington, D.C.	GDC	Heterog., tank	100	1961	
Armed Forces Radiobiology Research Institute (DOD).	DASA-TRIGA	Bethesda, Md.	GDC	U-Zr hydride, tank	100	1962	
Walter Reed Army Institute of Research (USA).	L-54	Washington, D.C.	AI	Homogeneous	50	1962	
Planned							
White Sands Missile Range Nuclear Effects Facility (USA).	WSMR	White Sands, N. Mex.	Kaman	Prompt burst		1963	

See footnotes at end of table.

PART III.—PRODUCTION REACTORS

1. MATERIALS PRODUCTION

Designation	Nuclear designer	Type	Location
OPERABLE			
B Reactor	du Pont	Graphite	Hanford, Wash.
D Reactor	du Pont	Graphite	Hanford, Wash.
F Reactor	du Pont	Graphite	Hanford, Wash.
C Reactor	GE	Graphite	Hanford, Wash.
DR Reactor	GE	Graphite	Hanford, Wash.
H Reactor	GE	Graphite	Hanford, Wash.
KE Reactor	GE	Graphite	Hanford, Wash.
KW Reactor	GE	Graphite	Hanford, Wash.
R Reactor	du Pont	Heavy water	Savannah River Plant, Aiken, S.C.
P Reactor	du Pont	Heavy water	Savannah River Plant, Aiken, S.C.
K Reactor	du Pont	Heavy water	Savannah River Plant, Aiken, S.C.
L Reactor	du Pont	Heavy water	Savannah River Plant, Aiken, S.C.
C Reactor	du Pont	Heavy water	Savannah River Plant, Aiken, S.C.
BEING BUILT			
New Production Reactor [43]	GE	Graphite	Hanford, Wash.

2. PROCESS DEVELOPMENT

Name (all owned by AEC)	Designation	Location	Nuclear designer	Type	Power kw(t)	Start-up
OPERABLE						
Process Development Pile [44]	PDP	Savannah River Plant, Aiken, S.C.	du Pont	Heavy water	1	1953
Physical Constants Test Reactor	PCTR	Hanford, Wash	GE	Graphite	0.1	1955
Thermal Test Reactor No. 2	TTR-2	Hanford, Wash	GE	Graphite	0.1	1955
Standard Pile [44]	SP	Savannah River Laboratory, Aiken, S.C.	du Pont	Graphite	2 to 10	1953

OPERABLE						
Hanford 305 Test Reactor	HEW-305	Hanford, Wash	du Pont	Graphite	0.03	1944
Savannah River Test Pile 305	SR-305	Savannah River Plant, Aiken, S.C.	du Pont	Graphite	1	1953

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PART IV.—REACTORS FOR EXPORT

1. POWER REACTORS

A. Central-Station Electric Power

Name and/or owner	Location	Principal nuclear contractor	Type	Power [1]		Start-up
				Plant kw(e) Net	Reactor kw(t)	
OPERABLE						
Germany (Rhine-Westphalia Power Co., RWE)	Kahl-am-Main	GE	Boiling water	15,000	60,000	1960
Belgium (Center for the Study of Nuclear Energy, CEN)	Mol	West	Pressurized water	11,500	43,000	1962
BEING BUILT						
Italy (Project Enrico Fermi of SELNI, Edisonvolta)	Trina	West	Pressurized water	165,000	615,000	1964
Italy (Project ENSI of SENN) Garigliano Nuclear Power Station	Punta Fiume	GE	Boiling water	150,000	508,000	1964
Japan, Government of (JAERI)	Tokai-Mura	GE	Boiling water	12,500	45,000	1963
France (Franco-Belgium Society for Nuclear Energy of Ardennes—SENA).	Chooz	West	Pressurized water	210,000	825,000	1965
PLANNED						
West Germany (Kernkraftwerk-Rwe-Bayernwerk or KWB	Grundemn inger	GE	Boiling water	237,000	801,000	1965

See footnotes at end of table.

B. PROPULSION

Name	Owner	Designer	Type	Start-up
OPERABLE				
S5W for HMS Dreadnaught	Great Britain	West	S5W	1962

2. TEST, RESEARCH, AND TEACHING

A. GENERAL IRRADIATION TEST

Owner	Location	Principal nuclear contractor	Type	Power [1,21] kw(t)	Start-up
OPERABLE					
Japan, Government of (Atomic Energy Research Institute)	Tokai-Mura	AMF	Heavy water, tank	10,000	1960
Netherlands, Government of (Reactor Center)	Petten	AC	Tank (MTR)	20,000	1961
Sweden, Government of (Atomic Energy Company)	Studsvik	AC	Tank (MTR)	30,000	1960
PLANNED					
South Africa, Government of (Atomic Energy Board)	Pelindaba, S. Africa	AC	Tank	20,000	1963

B. RESEARCH

OPERABLE					
Austria, Government of (Seibersdorf Research Center)	Seibersdorf	AMF	Pool	5,000	1960
Brazil, Government of (University of Sao Paulo)	Sao Paulo	B&W	Pool	5,000	1957
Canada (McMaster University)	Hamilton, Ont	AMF	Pool	1,000	1959
China, Republic of (National Tsing-Hua University)	Hsinchu	GE	Pool	1,000	1961
Denmark, Government of (Atomic Energy Commission)	Riso	FW	Tank	5,000	1958
Germany, Federal Republic of (Technical University of Munich)	Munich	AMF	Pool	1,000	1957
Germany, Federal Republic of (Society for the Utilization of Nuclear Energy in Shipbuilding and Navigation, Inc.).	Geesthacht	B&W	Pool	5,000	1958
Greece, Government of (Atomic Energy Commission)	Athens	AMF	Pool	1,000	1961

Israel, Government of (Atomic Energy Commission)	Nebi Rubin	AMF	Pool	5,000	1960
Italy, Government of (National Committee for Nuclear Research)	Ispra	AC	Heavy water, tank	5,000	1959
Italy, Government of (National Committee for Nuclear Research)	Rome	GDC	TRIGA-Mk II	100	1960
Italy (SORIN Nuclear Center)	Saluggia	AMF	Pool	1,000	1959
Japan (Musashi University)	Kawasaki City	GDC	TRIGA-Mk II	100	1962
Japan (Rikkyo University)	Yokosuka City	GDC	TRIGA-Mk II	100	1961
Korea, Government of (Atomic Energy Commission)	Seoul	GDC	TRIGA-Mk II	100	1962
Netherlands, Government of, Delft Technical University [47]	Delft	AMF	Pool	100	1962
Portugal, Government of (Nuclear Energy Board)	Sacavem	AMF	Pool	1,000	1961
Spain, Government of (Nuclear Energy Board)	Moncloa	GE	Pool	3,000	1958
Switzerland, Government of (Reactor, Inc.)[45]	Wuerenlingen	ORNL	Pool	1,000	1955
Thailand (Chulalongkorn University)	Bangkok	CW	Pool	1,000	1962
Turkey, Government of (Atomic Energy Commission)	Istanbul	AMF	Pool	1,000	1962
Venezuela, Government of (Institute of Neurology and Brain Research)[46]	Caracas	GE	Pool	3,000	1960
BEING BUILT					
Iran, Government of (University of Tehran)	Tehran	AMF	Pool	5,000	1963
Italy (Naval Academy, University of Pisa, and C.A.M.E.N.)	Livorno	B&W	Pool	5,000	1963
Indonesia (Institute for Atomic Energy)	Bandung	GDC	TRIGA-Mk II	100	1963
Japan (Kyoto University)	Kyoto	IC	Tank	1,000	1965
Pakistan, Government of (Atomic Energy Commission)	Rawalpindi	AMF	Pool	5,000	1963
Phillipines, Government of (National Science Development Board)	Quezon City	GE	Pool	1,000	1963
Thailand (Chulalongkorn University)	Bangkok	CW	Pool	1,000	1962
Vietnam, Government of	Dalat	GDC	TRIGA-Mk II	100	1963
PLANNED					
Yugoslavia, Federal People's Government of (Josef Stefan Nuclear Institute).	Ljubljana	GDC	TRIGA-Mk II	100	1963
Italy (University of Pavia)	Lombardy	GDC	TRIGA-Mk II	250	1964
Pakistan, Government of (Atomic Energy Commission)	Rawalpindi	AMF	Pool	5,000	1963

See footnotes at end of table.

C. TEACHING

Owner	Location	Principal nuclear contractor	Type	Power [1,21] kw(t)	Start-up
OPERABLE					
Australia (Atomic Energy Commission)	Lucas-Heights, New South Wales.	ARSS	UTR-10	10	1961
Austria, Government of (Vienna Polytechnic Institute)	Vienna	GDC	TRIGA-Mk II	100	1962
Brazil (University of Minas Gerais)	Belo Horizonte	GDC	TRIGA-Mk I	30	1960
Congo, Government of (University of Lovanium)[48]	Leopoldville	GDC	TRIGA-Mk I	50	1959
Denmark, Government of (Atomic Energy Commission)	Riso	AI	L-55	0.5	1957
Finland, Government of (Institute of Technology)	Helsinki	GDC	TRIGA-Mk II	100	1962
Germany, Federal Republic of (Universities of Frankfurt and Darmstadt)	Frankfurt	AI	L-54	50	1958
Germany (Interatom, Inc.)[49]	Duisburg	AI	L-77	Negligible	1958
Italy (University of Palermo)	Palermo	AGN	201-110	Negligible	1960
Italy (University of Milan)	Milan	AI	L-54	50	1959
Japan, Government of (Atomic Energy Research Institute)	Tokai-Mura	AI	L-54	50	1957
Japan (Kinki University)	Osaka	ARSS	UTR-10	Negligible	1961
Switzerland (University of Basel)[50]	Basel	AGN	211-100	Negligible	1958
Switzerland (University of Geneva)[51]	Geneva	AGN	201-111	Negligible	1958
West Berlin, City of (Institute for Nuclear Research)	West Berlin	AI	L-54	50	1958
PLANNED					
Columbia (Columbian Institute of Nuclear Affairs)	Bogota	AMF	Argonaut	10	1963
Germany (Johannes Gutenberg, University of Mainz)	Mainz	GDC	TRIGA-Mk II	30	1963
Japan (Tokai University)	Nagoya	ARSS	UTR-10	Negligible	
United Kingdom, Government of (Scottish Research Reactor Center)	East Kilbirde	ARSS	UTR-100	100	1963

A. Identification of Facilities

Abbreviation	Name and location of facility	Operator	No. of cells	No. of control panels
AC	Allis-Chalmers Critical Experiment Facility, Greendale, Wis	Owner	1	1
AI	Atomics International Critical Experiment Laboratory (AEC), Santa Susana, Calif	Owner	3	3
Alco	Alco Products, Inc., Schenectady, N.Y	Owner	1	1
ANL	Argonne National Laboratory (AEC), Lemont, Ill	ANL	5	5
ANL-ID	Argonne National Laboratory, Idaho Division (AEC), NRTS, Idaho	ANL	1	1
ARMF	Advanced Reactivity Measurement Facility (AEC), NRTS, Idaho	PPC	1	1
ATRC	Advanced Test Reactor Critical Facility (AEC), NRTS, Idaho	PPC	1	1
Bettis	Bettis Plant (AEC), Pittsburgh, Pa	West	6	6
BMI	Battelle Memorial Institute, West Jefferson, Ohio	Owner	1	1
BNL	Brookhaven National Laboratory (AEC), Upton, N.Y	BNL	2	2
B&W	The Babcock & Wilcox Co., Lynchburg, Va	Owner	3	3
CANEL	Connecticut Advanced Nuclear Engine Laboratory (AEC), Middletown, Conn	P&W	2	2
Comb	Nuclear Engine Laboratory of Combustion Engineering, Inc., Windsor, Conn	Owner	3	2
Cornell	Cornell University Zero Power Reactor, Ithaca, N.Y	Owner	1	1
ETRC	Engineering Test Reactor Critical Facility (AEC), NRTS, Idaho	PPC	1	1
GDC	General Dynamics Corp., San Diego, Calif	Owner	2	2
GE	General Electric Company, Vallecitos Laboratory Experimental Physics Facility, Pleasanton, Calif	Owner	1	1
GEANP	Evendale Critical Experiment Facility (AEC), Evendale, Ohio	GE	2	2
HAN-CML	Hanford Critical Mass Laboratory (AEC), Hanford, Wash	GE	1	1
HAN-PRCF	Plutonium Recycle Critical Facility (AEC), Hanford, Wash	GE	1	1
KAPL	Knolls Atomic Power Laboratory (AEC), Schenectady, N.Y	GE	7	7
LAC	Georgia Nuclear Laboratory, Dawsonville, Ga	Lockheed	1	1
LASL	Los Alamos Scientific Laboratory, Los Alamos, N. Mex	LASL	3	3
Livermore	University of California Lawrence Radiation Laboratory Critical Assembly Area (AEC), SAGA Building, Livermore, Calif.	UCLRL	4	3
LPTF	Low Power Test Facility (AEC), NRTS, Idaho	GE	2	2
Martin	Martin Co., Middle River, Md	Owner	3	3
NAA	North American Aviation, Inc., SNAP Critical Experimental Facility (AEC), Santa Susana, Calif	AI	1	1
NASA	Lewis Flight Propulsion Laboratory, Sandusky, Ohio	Owner	1	1
ORNL-CF	Oak Ridge National Laboratory Critical Facility (AEC), Oak Ridge, Tenn	ORNL	3	5
ORNL-PCA	Pool Critical Assembly, BSF Pool (AEC), Oak Ridge, Tenn	ORNL	1	1
UCLRL-NTS	University of California Lawrence Radiation Laboratory (AEC), NTS, Nev	UCLRL	1	1
UNC	United Nuclear Corp., Development Division, Pawling, N.Y	Owner	1	1
West	Westinghouse Reactor Evaluation Center Critical Experiment Station (CES), Yankee Critical Facility (YCF), and Large Reactor Critical Facility (LRX), Waltz Mill, Pa.	Owner	3	3

See footnotes at end of table.

B. Identification of Experiments and Studies

B.1. Civilian

Facility	Subject of current experiment or study	Designation	Start-up
Operable			
AC	Vacant	CRBR-CX	1959
AI, AETR	Nuclear properties of epithermal reactor systems	AETR	1960
AI, OMCA	Nuclear properties of organic-moderated systems	OMCA	1959
AI, SCGA	Nuclear properties of sodium-graphite systems	SCGA	1959
ANL, Building 316, Cell A [52]	Argonne Thermal Source Reactor (Formerly called ZPR-4)	ATSR	1957
ANL, Building 316, Cell B	Contains ZPR-7 facility; high conversion (Hi-C) critical experiments	ZPR-7	1956
ANL, Building 316, Cell C	Flux-trap configuration critical studies—(Formerly ZPR-5)		1957
ANL-ID	Fast critical mass determinations	ZPR-3	1955
Bettis	PWR core 2 mock-up	PWR-FA	1954
Bettis	PWR physics	PWR-CC	1962
BMI, Cell 1	Experiments with plastic-moderated assembly	BMI-CX	1957
BNL, Building T-526	Exponential and critical assembly		1956
B&W, Cell 1	Advanced Test Reactor Criticals		1962
B&W, Cell 2 [53]	Spectral Shift Control Reactor		1958
B&W, Cell 3 [53]	Small lattice experiment		1958
Comb., Building 1, Cell 1	Vacant		
Comb., Building 2, Cell 1	Boiling nuclear superheat critical experiment	BONUS	1961
Comb., Building 2, Cell 2	Integral nuclear superheat core configuration	NUSU	1960
Cornel	Reactor physics research	ZEPR	1962
ETR-MTR Area, ARMF, (PPC)	Reactor physics constants and reactivity changes caused by test reactor irradiation	ARMF	1960
ETR-MTR Area, ETRC, (PPC)	ETR physics, core loading and core design	ETRC	1957
GDC	Experimental Beryllium Oxide Reactor critical experiment	EBOR-CX	1962
GDC	Maritime Gas Cooled Reactor critical experiment	MGCR-CX	1960
GE, Cell 1	Nuclear superheat core configuration		1961
HAN-CML	*Plutonium Solution Criticals*	CML	1961
HAN-PRCF	Plutonium Recycle Criticals	PRCF	1962
LASL, Kiva 1	Cold criticals for ROVER reactors	ZEPO and Honeycomb.	1957
LASL, Kiva II	Physics measurements of thin enriched-uranium foils in thick D_2O cold critical experiments	Cavity	1960
LASL, Kiva III	Cold critical operation of Rover test reactors, environmental chamber, general purpose critical assembly.		1962

Martin, Cell 1	Martin power reactor experiments		1957
Martin, Cell 2	Homogeneous dispersions in a plastic of uranium, stainless steel, and boron		1958
NASA, Materials and Stresses Building [54]	NASA Test Reactor critical experiments (ZPR–I system)	NASA–ZPR–I	1959
ORNL–CF, Building 9213, Cell E	Uranium-paraffin experiments related to physics and safety of homogeneous reactors	CA–28	1950
ORNL–CF, Building 9213, Cell S	Comparison of nuclear properties of U–235 and U–233		
ORNL–CF, Building 9213, Cell W	Reactor-physics and nuclear safety studies with homogeneous uranium solutions; slightly enriched uranium lattices in water; TSR–2 tests; investigations of neutron absorbers as poisons in chemical-processing equipment.		1950
ORNL–PCA, Building 3010	Physics research on reactivity effects	PCA	1958
UNC	Pawling lattice test rig	PLATR	1959
West., CES	Reactor-fuel-measurement facility design		1958
West., LRX	Vacant	CVTR-LRX	1961
West., YCF	Loose lattice critical experiments		
Being Built			
ANL, Building 315, Cell 5	Basic fast reactor theoretical studies	ZPR–6	1963
ANL, Building 315, Cell 4	Coupled fast core—thermal breeder blanket investigations	ZPR–9	1963
BNL, Building T–526A	Exponential and Critical Assembly		1963
Cornell	Reactor Physics Research	ZEPR	1962
Martin, Cell 3	Liquid Fluidized Bed Reactor critical experiment facility	LFBR–CX	1963
NASA, Materials and Stresses Building [54]	NASA Zero Power Reactor II solution-type critical	NASA–ZPR–II	1963
Planned			
ATR Area, ATRC (PPC)	ATR physics, core loading and core design measurements	ATRC	1964

See footnotes at end of table.

B. 2. MILITARY

Facility	Subject of current experiment or study	Designation	Start-up
OPERABLE			
Alco	Vacant	APPR-s	1956
Bettis	Clean critical experiments [55]	RDA-CF	1961
Bettis	Surface-ship physics	SS-CF	1957
Bettis	Physics measurements	SPE	1960
Bettis	High-temperature physics and mock-up	HTTF	1959
CANEL, Physics Building, Cell 1	Vacant		
CANEL, Physics Building, Cell 2	Vacant		
GEANP-1	Vacant		
GEANP-2	Vacant		
KAPL	Physical data	SHCA	1962
KAPL	Reactor physics studies with plastic moderator and mock-up	PMA	1954
KAPL	Submarine advanced reactor mock-up	ATR	1954
KAPL	SAR physics and mock-up	FPR	1956
KAPL	D1G cold-water mock-up	CWA	1958
KAPL	SAR high-temperature and -pressure physics and mock-up	PTR	1958
KAPL	Cold Water Test Assembly	CWTA	1960
LAC	RER core configurations	CERF	1958
LASL, Kiva II	Plated bare-plutonium sphere studies	Jezebel	1954
LASL, Kiva II	Jacketed enriched-core lateral and base reflector of water studies, used as neutron sources for exponential column.	Hydro	1956
LASL, Kiva II	Water immersion safety tests	Water tank	1961
LASL, Kiva II	Spherical metal cores in thick metal reflector	Flattop	1957
LASL, Kiva I	Critical configuration safety tests	Comet II	1953
LASL, Kiva II	Critical configuration safety tests	Planet	1952
Livermore, SAGA Building	Critical measurements with different geometrics		1953
Livermore, SAGA Building	Project PLUTO cold critical experiments		1957
Livermore, SAGA Building	Fast critical experiments	Kukla	1959
Livermore, SAGA Building	Tory-II critical experiments		1960
LPTF, Cell 1 [56]	Hot critical experiments	HOTCE	1958
LPTF, Cell 2 [56]	630-A critical experiment	MARIA	1962
NAA-A1	Criticals for SNAP reactors		
UCLRC, NTS, Nevada	Hot criticals for Tory-II (Project PLUTO)	Hot Box	1959

FOOTNOTES

[1] Power capacity figures are based on the best available information. In some cases future modification in plans may cause changes. In all instances thermal capacity of the nuclear reactor is given; the electrical output, when shown, is the net electrical capacity of the power plant. For reactors being built or planned,, plant capacity is rounded to the nearest hundred kilowatts.

[2] The Shippingport station is provided with a turbogenerator rated at 100,000 kw(e). Modification of the reactor plant to permit operation at 150,000 kw(e) gross equivalent is in progress.

[3] This project is under the Power Demonstration Reactor Program.

[4] In the Consolidated Edison Indian Point plant the 585,000 kilowatts of thermal energy from the reactor is increased to 795,000 kilowatts thermal by an oil-fired superheater to produce 255,000 net kilowatts of electricity. Thermal capacity of the reactor is equivalent to about 151,000 kilowatts of electricity; the 210,000 thermal kilowatts from the superheater is equivalent to about 104,000 kilowatts of electricity.

[5] The Enrico Fermi plant will be provided with a turbogenerator rated at 150,000 kw(e) and may reach this gross output with later cores.

[6] In the proposed Ravenswood plant the 2,030,000 kilowatts of thermal energy from the reactor is increased to 2,850,000 kilowatts by an oil fired superheater. The reactor will account for about 70% of the heat input to the system and about 66% of the electrical output.

[7] The 58,200 kilowatt thermal capacity of the Elk River Reactor is increased to 73,000 kilowatts thermal by a fossil-fired superheater to produce 20,000 net kilowatts of electricity. Thermal capacity of the reactor is equivalent to about 15,000 kilowatts of electricity; the 14,800 thermal kilowatts from the superheater is equivalent to about 5,000 kilowatts of electricity.

[8] In the CVTR plant the 56,000 kilowatts of thermal energy from the reactor is increased to about 66,000 thermal kilowatts by an oil-fired superheater to produce 17,000 net kilowatts of electricity. Thermal capacity of the reactor is equivalent to about 15,000 kilowatts of electricity; the 10,000 thermal kilowatts of the superheater is equivalent to about 2,000 kilowatts of electricity.

[9] EBWR was successfully operated at a power level of 62,000 kw of heat in experiments on March 20, 1958. It has been converted to a 100,000-kw thermal plant, but its electrical output is limited by turbogenerator capacity. Operation of EBWR in the Boiling Water Program will be closed out shortly. The plant achieved full power of 100,000 kw(t) in November 1962. After appropriate modifications the reactor will be used in support of the Plutonium Recycle Program.

[10] This facility was originally built and operated in 1954 as the Boiling Reactor Experiment No. 2 (BORAX–2). With the addition of a turbogenerator, it operated during 1955 as BORAX–3. BORAX–4 was a further modification, which operated from December 1956 until June 1958, when the experiment was shut down.

[11] Gross electrical kilowatt output is shown for EBR–1 in the tabulation. In a trial run on December 21 and 22, 1951, EBR–1 generated the world's first electric power from nuclear energy and was the first to demonstrate that the use of sodium-potassium alloy as a liquid-metal coolant is compatible with breeding economy. Criticality with the third core was achieved in November 1957. Criticality with a plutonium-bearing core (Mark IV) was achieved in November 1962.

[12] Saturated steam will be supplied by VBWR or a separate gas-fired boiler. At a later date GE plans to make interconnections and operate the EVESR at thermal power levels up to 23 Mw to superheat saturated steam from either or both the VBWR or the gas-fired boiler and to discharge a portion of the superheated steam generated in the EVESR to the VBWR turbine-condenser system.

[13] The purpose of UHTREX, formerly known as Turret, is to investigate problems associated with ultra-high-temperature gas-cooled reactors using unclad fuel elements.

[14] EBOR is to be constructed in the Shield Test Pool Facility, which was formerly used for shielding studies in the Aircraft Nuclear Propulsion Program.

[15] This reactor experiment utilizes technology developed under the Aircraft Nuclear Propulsion Program, which was cancelled early in 1961.

[16] The Fast Reactor Core Test Facility will be used to perform a series of experiments. The 20 Mw(t) is an upper limit for the experiments and not a reactor design figure.

[17] SNAP reactors are being developed for both civilian and military applications.

[18] In August 1958 the MTR was operated up to 30 Mw(t) using plutonium as a fuel. It demonstrated the ability of plutonium fuel elements to perform satisfactorily in a high flux power reactor.

[19] The WTR was shut down in March 1962 because of insufficient business to meet operating costs.

[20] BSR–2, which became operable in 1959, is a stainless-steel-UO_2 core that can be used alternately in the same facility with BSR–1 (aluminum alloy core).

[21] Reactors whose thermal power output is less than 50 watts are shown as having negligible power output. The thermal power of these reactors is as follows: AGN 201's, 100 Mw; AGN 201M's, 5 watts; AGN 201P's, 20 watts; AGN 211's, 15 watts; AI's L–47 and L–77, 10 watts; ARSS' UTR–1, 1 watt; and NDA's PRR, 5 watts.

[22] In 1943, the Manhattan Engineer District disassembled Chicago Pile 1 and rebuilt it at Palos Park, Ill., as Chicago Pile 2. CP–2 had a thermal power level of 10 kw.

[23] LITR began as a mechanical model of the MTR. After MTR engineering aspects were proved, nuclear fuel, control devices, shielding, and instruments were added; and the reactor, called MTR critical experiment, went critical for the first time in the spring of 1950. Research facilities were added, and power was increased to the present level in the fall of 1951.

[24] AE–6, also designated WBNS, was built and first operated at Downey, Calif. It was moved to Santa Susana in 1957.

[25] Ownership of the Curtiss-Wright Research Reactor Facility was transferred to Pennsylvania State University in December 1960. The reactor is being maintained on a standby basis pending issuance of an operating license to the university.

[26] The TRIGA pulsing reactor is capable of being pulsed to peak power levels of approximately 1,200,000 kw for fractions of a second at repeated intervals.

[27] After the assembly and operation of this reactor in the Government exhibit at Geneva in September 1958, it was dismantled and returned to ANL, where it was rebuilt as a 250-kw(t) Juggernaut.

[28] RER was previously used in the terminated ANP program. A license authorizing Lockheed to operate the USAF owned reactor to do commercial irradiation work was issued in July 1962. Power level was limited to 1000 kw(t) at the time. On August 24, 1962, the AF transferred the Georgia Nuclear Laboratory to the General Services Administration for disposition. On November 23, 1962, the AEC requested transfer of the facilities to the AEC. Lockheed continues to operate the facility.

[29] This reactor was shipped abroad for exhibition purposes in Pakistan and Egypt in 1960.

[30] TRIGA–Mk II was operated at the New Delhi World Agricultural Fair in 1960. It has been dismantled for storage in California by GDC.

[31] The original 10-kw research reactor at Raleigh, N.C., was started up in 1953 and was dismantled in 1955. The reactor was reactivated with a 500-watt core in March 1957. Early in 1959, the reactor was modified for 100-watt operation and moved to a new location in the Nuclear Science Laboratory, and a new 10-kw heterogeneous-core Argonaut type reactor was built in the original RRR shield vacated by the homogeneous core.

[32] This reactor was exhibited at Buenos Aires in the fall of 1960, in Rio de Janeiro in the spring of 1961, in Mexico City in the spring of 1962, in Santiago, Chile, in the fall of 1962, and is to be exhibited at Bogota, Colombia, in the spring of 1963.

[33] These AGN reactors will not be completed until firm orders are received from customers.

[34] Reactors in the Army power program are identified by symbolic nomenclature to reflect mobility characteristics, power range, development sequence, and field sequence. The first capital letter indicates mobility characteristics: S (stationary operation), not designed for subsequent relocation; P (portable), semimobile, stationary operation, capable of being dismantled and reassembled for use in successive locations; M (mobile), capable of being moved intact, or virtually intact, for use in successive locations. The second capital letter indicates the power range, as measured by design capacity for continuous operation: L (low), 100 to 1000 kw(e); M (medium), 1000 to 10,000 kw(e); H (high), 10,000 kw(e) or more. Arabic numerals indicate order in which plants having the same mobility and power characteristics are initiated. If not followed by an additional letter, the designation indicates a prototype or pilot plant. The last capital letter (when present) indicates the alphabetical order in which field plants of a specific type are initiated.

[35] PM–2A produces 1 million Btu/hr in the form of steam for space heating and snow melting in addition to electrical output.

[36] SM–1A produces 38 million Btu/hr for space heat in addition to electrical output.

[37] All reactors in the naval propulsion program are of the pressurized-water type except the sodium-cooled system formerly installed in the *Seawolf*. Symbols in the type column indicate (1) the ship type for which the reactor is designed, (2) the sequence number of the plant design by the principal contractor for each ship type, and (3) the designator letter for the name of the contractor responsible for the design of the reactor plant. When appearing as the first letter of the symbol, S indicates submarine; D, destroyer type; C, cruiser; and A, aircraft carrier. The principal-contractor designation letters are W for Westinghouse, G for General Electric, and C for Combustion Engineering.

[38] USS *Seawolf*, originally commissioned with a sodium-cooled reactor in March 1957, was recommissioned with a pressurized-water reactor on September 30, 1960.

[39] GCRE was shut down in April 1961 following a pressure vessel failure. The reactor was dismantled early in 1962, and the remainder of the plant was placed in standby. Design of a replacement vessel is under way.

[40] PM–1 produces 7 million Btu of space heat per hour in addition to electrical output.

[41] With the termination of the Aircraft Nuclear Propulsion Program early in 1961, these reactors have been placed on a standby status.

[42] Upon completion of construction and after initial start-up and check-out for proper operation, the NETR will be placed on a standby status.

[43] The design of this reactor incorporates features making possible conversion to permit power take-off. Such work is going forward pending final constructive authorization by the Congress.

[44] PDP and SP are also used in the Heavy Water Power Reactor Program.

[45] This is the 1955 Geneva Conference reactor rebuilt with increased power and now operating at Wuerenlingen, Switzerland.

[46] The Venezuela Research Reactor was shut down in September 1961. It is expected that the reactor will not be operated again until 1964 or 1965.

[47] The Netherlands research reactor was originally operated at the Amsterdam International Exhibition in June 1957; major portions of the exhibition reactor system were used to fabricate the present reactor.

[48] This TRIGA reactor was operated at the 1958 International Conference in Geneva prior to shipment to the University of Lovanium. It began operating at the University of Lovanium in June 1959. It is the first reactor to be operated on the African continent.

[49] This L–77 reactor was operated in the commercial exhibit of the 1958 International Conference in Geneva. It is presently in storage without fuel at Interatom, Inc.

[50] This reactor was operated in the International Science Section of the Brussels International Exhibition, April 15 to October 1, 1958, prior to transfer to the University of Basel.

[51] AGN 201–111 was operated in the commercial exhibit of the 1958 International Conference in Geneva prior to transfer to the University of Geneva.

[52] Zero-power experiments of historical interest previously conducted in ANL facility cells include the *Nautilus* core design (ZPR–1), the Savannah River reactor design (ZPR–2, and a series of fast-neutron studies (ZPR–4) and interactions between two basic systems (ZPR–5). The following experiments have been performed in the ZPR–7 facility: thorium, uranium, deuterium criticals (THUD), and a series of flux-trap criticals for the Argonne High Flux Research Reactor.

[53] B&W cells 2 and 3 share a control panel; only one cell can be operated at any one time.

[54] The NASA–ZPR–I and –ZPR–II systems will be operated from the same control panel, but it is possible to operate only one system at a time.

[55] The cell has one control panel for two pots. Experiments may be operated in either pot, but not simultaneously.

[56] HOTCE in LPTF is to be dismantled late in 1962. The experiment in Cell 2 was dismantled early in 1962, and the cell is available for other work.

APPENDIX 8

Final Report of SL–1 Accident Investigation Board

Memorandum

September 5, 1962

To: A. R. Luedecke
General Manager

From: Curtis A. Nelson, Chairman
SL–1 Board of Investigation

Subject: FINAL REPORT OF THE SL–1 BOARD OF INVESTIGATION

The Board herewith submits its final report concerning the SL–1 incident which occurred at the National Reactor Testing Station on January 3, 1961.

Phase 3 of the SL–1 Recovery Operation is now complete and it seems highly unlikely that any significant additional information will become available concerning the incident.

The direct cause of the incident clearly appears to have been manual withdrawal by one or more of the maintenance crew of the central control rod blade from the SL–1 core considerably beyond the limit specified in the maintenance procedure. There is insufficient evidence to establish the actual reason or motive for such abnormal withdrawal. One or more of the following circumstances may have resulted in the abnormal manual withdrawal of the blade: Inadequate or faulty procedure or training (the Board has no reason to change its previous conclusion that the training of the military personnel for this maintenance operation was adequate); "human error," for example, incorrect manipulation of the blade owing to preoccupation of the manipulator with extraneous matters; involuntary performance of the individual manipulating the blade as a result of unusual or unexpected stimulus; deliberate malperformance motivated, for example, by emotional stress or instability.

The Board has had access to the personnel files, including medical examinations, of the three men involved, as well as the results of many interviews with their associates and relatives. Opinions vary on the relative probability of the possible alternatives. Because of the highly subjective and speculative nature of such opinions, the Board is unable to conclude that any one alternative is the most probable.

It is known that certain undesirable conditions had developed with respect to the reactor and its operation, some having their origin in the design of the reactor and others in the cumulative effects of reactor operation, which do not now appear to have had a direct relation to the immediate cause of the incident. The Board observes, however, that the overall effect of these conditions produced an environment in which the possibility of an incident may have been increased beyond that necessary.

We continue to hold that the immediate responsibility for safe operation of the SL–1 was that of the onsite operating contractor, Combustion Engineering, Inc., and that, by virtue of the effect on contractor operations of financial program and other direction by the AEC Idaho Operations Office and the Head-

quarters Division of Reactor Development, these organizations shared in the responsibility for the safe operation of the SL–1 plant.

We strongly recommend that the Commission take the necessary steps to assure that the facts, conclusions and implications relating to the SL–1 incident be disseminated to the interested public. While we believe that the Board has completed its assignment with the submission of the attached report, individual Board members and consultants will, of course, be available to consult with and advise those persons who may be selected by the Commission to effect such dissemination.

Enclosure:
Final Report, SL–1 Board of Investigation

UNITED STATES ATOMIC ENERGY COMMISSION

Final Report on The SL–1 Incident, January 3, 1961 The General Manager's Board of Investigation

CURTIS A. NELSON, *Chairman*
CLIFFORD K. BECK
PETER A. MORRIS
DONALD I. WALKER
FORREST WESTERN

1. *Introduction*

The General Manager's Board of Investigation for the SL–1 incident issued a preliminary report, dated January 27, 1961; a more complete report, dated May 10, 1961,[1] and a brief interim report, released to the press on April 3, 1962. The Board met again in Idaho Falls, Idaho, on August 20, 21, and 22, 1962, to consider all available additional reports or other information and comment from Commission contractors, staff or other interested parties. The primary source of additional information was the "Final Report of SL–1 Recovery Operation, May 1961, through July 1962." The report was prepared by the General Electric Company, Nuclear Materials and Propulsion Operation, under contract with the Atomic Energy Commission. Additional information was received during open sessions of the Board from representatives of the General Electric Company, Combustion Engineering, Inc., Argonne National Laboratory, and the AEC Idaho Operations Office.

It is the purpose of the Board, in this final report, to describe a reasonable hypothesis for the cause and course of the incident and to provide, or make reference to, such other new information as is now available and significant.

2. *Summary*

The direct cause of the incident clearly appears to have been the manual withdrawn by one or more of the maintenance crew of the central control rod blade from the SL–1 core considerably beyond the limit specified in the maintenance

[1] This report, and a transmittal letter to the General Manager, were reproduced as a committee print of the Joint Committee on Atomic Energy, 87th Congress, 1st Session, June 1961.

procedure. The reason or motive for the abnormal withdrawal is considered highly speculative, and it does not appear at all likely that there will ever be any reason to change this judgment.

The Board is able, however, to reaffirm the principal conclusions hitherto stated. While the original details of findings and conclusions are understandably modified and expanded by the information and analysis resulting from the dismantling, examination, and evaluation of the SL–1 facility, there is no significant difference in the conclusions now reached.

All evidence supports a conclusion that a nuclear excursion took place as a result of the manual withdrawal from the reactor core of the central control blade to a position sufficient to produce an energy release of the magnitude determined from postincident studies.

Efforts were made to discover evidence of a chemical explosion, or other nonnuclear mechanism, deliberately or accidentally induced, which might have been the initiating cause of reactivity changes. No such evidence was found.

3. *Details*

While none of the evidence and analyses made available since the previous reports of the Board materially affects the Board's previous conclusions, it does seem appropriate to restate those conclusions explicitly, and also to state other conclusions which may now be formulated in the light of all of the additional information, evaluation and comments that have become available.[2] This restatement follows the format of the conclusions of the Board's May 10, 1961, report (paragraph 8, page 36 of the Joint Committee Print).

A. An explosion occurred in the SL–1 reactor at approximately 9 p.m. on January 3, 1961, resulting in the death of three persons and in damage to the reactor and to the reactor facility. High radiation levels (up to as much as 1000 roentgens per hour) were present near the reactor immediately following the incident. These activity levels decreased with time as would be expected of the known inventory of radioactive fission products. From observed activity levels, measurements of local contamination and activity of gaseous effluents, it has been estimated that approximately 5 percent of the gross fission product activity contained in the core as a result of prior reactor operation and from the excursion were released to the building environs. Estimates of such release based on a rough inventory of the fuel recovered from the reactor vessel are higher by a factor of 2 or 3.

B. Two members of the three man maintenance crew were killed instantly by the explosion. The third died within approximately 2 hours as a result of an injury to the head.

C. The explosion resulted from a nuclear excursion. The exposure to thermal neutrons (nvt) in the reactor room adjacent to the reactor is estimated from activation data to have been approximately 10^{10}n/cnf^2. It now appears that neutrons causing this exposure originated from the expelled fuel material and from the core, particularly during the time the core was elevated above its normal position (when the reactor vessel moved upward to hit the ceiling and then returned to approximately its initial position).

[2] The Board has not included as a part of this final report all the reports of work done by others, but references to this work are made in the body of the report. The reports are listed on the last page.

D. Initial chemical and radioactivity measurements on a single fragment of reactor fuel ejected by the explosion, assumed to be representative of the total fuel, indicated within broad limits of error a nuclear event which produced 1.5×10^{18} fissions, or 50 megawatt-seconds of energy. Early estimates, based on decay of gaseous activity and on analogy with SPERT and BORAX experimental results, gave a range from 100 to 500 megawatt-seconds. These initial estimates were recognized to be uncertain by factors up to 2 or 3. It has also been recognized that the difference in thickness of the fuel plates of the SL–1 from the BORAX–1 destructive experiment and the probable difference in reactor period make impossible a direct comparison of physical damage on the basis of total energy release. The SL–1 incident period is now thought to be approximately twice that for BORAX, i.e., 4 milliseconds.

The best estimate of total nuclear energy release is now thought to be that determined from analysis of the induced activity of cobalt-aluminum wire samples (placed in the core on the day of the incident to measure neutron flux distribution during power operation) which were activated only as a result of the nuclear event. This estimate—130 megawatt-seconds—is believed to be accurate within approximately 20 percent.

A highly significant aspect of the consequences of this energy release disclosed during the postincident physical examination of the SL–1 facility was the discovery that a severe water hammer occurred within the reactor vessel. This water hammer was the direct cause of most of the external physical damage resulting from the incident.

The evidence for a water hammer effect is very convincing. The observed effects on the reactor vessel, the collapse of shield plug extension tubes and the vertical displacement of the reactor vessel, together with the results of model tests conducted by the Aberdeen Proving Ground, are all more than just qualitatively in agreement. This mechanism (water hammer effect) for production of observed physical effects also gives support to the hypothesis of a single nuclear transient rather than two or more bursts.

E. At the time of the explosion, the reactor crew was most probably engaged in reassembly of the number 9 control rod (the central control rod) assembly. To the Board, it appears quite plausible that the shift supervisor and the other regular member of the crew were located on top of the reactor vessel at the time of the explosion. The third member of the crew, who was a trainee, might have been partially over the reactor top or close to the edge of the reactor top. Based on medical evidence of injury, location of the men after the incident and knowledge of the individual capabilities and job assignments, it appears reasonable to hypothesize that the supervisor was in a crouched or squatting position which would be normal for manipulation of the C-clamp during the reassembly of the number 9 control rod drive. Similarly, it would appear reasonable to hypothesize that the regular crew member was located in a position for lifting the number 9 control rod assembly with the handling tool. There is no direct evidence to corroborate these hypothetical assertions.

The pressure history of the interior of the reactor vessel appears to be complicated in time and location by the occurrence of the water hammer (which could take place only because of the space between the top of the water in the vessel and the top of the vessel itself). The initial pressure buildup in the region of the core appears to have been to approximately 500 psi, which pressure was sustained for a time adequate to accelerate a slug of water upward so that it slammed against the reactor head. Peak pressure in the vicinity of the reactor head approached 10,000 psi. (The actual peak pressure is somewhat uncertain because of a possible cushioning effect of compressed air

above the water. Transfer of momentum is not affected by this uncertainty, however.)

Results of model studies with conventional explosives, while not precise, do indicate a strong likelihood that a pressure of the order of 500 psi persisted for a time after the initial pressure increase which was long compared to the nuclear transient, and caused most of the water to be ejected from the vessel rather than falling back into the region of the core. This result also supports the hypothesis of a single nuclear event.

F. The reactor vessel moved upward as a result of the water hammer (with an initial velocity estimated at 27 feet per second) allowing surrounding insulation and head shielding material to be expelled onto the reactor room floor. As the vessel started to move upward, shield plugs were ejected upward from the reactor. Structural damage to the building was not great.

Blast damage extended over the whole core and generally created a void in the central region compressing core components toward the periphery. Melting and hence presumably the ability to release fission fragments—was confined to about 20 percent of the core.

Definite evidence of a metal-water reaction resulting from the contact of hot aluminum with water—adding energy to the nuclear event—is provided by the presence of alpha-phase alumina in the reactor vessel, which could have been formed only by such a reaction. The energy contributed by this source is estimated to be 24 megawatt seconds, based on the amount of alpha-phase alumina recovered, plus rough estimates of such material as was not recovered.

While the nuclear excursion was probably terminated by destruction of the core and ejection of the moderator, it is significant that an incident of this kind could incapacitate the control and safety rod system and destroy the effectiveness of an emergency boron injection system and an emergency cooling system.

G. Some gaseous fission products, including radioactive iodine, escaped to the atmosphere outside the building and were carried downwind. Particulate fission product material was largely confined to the reactor building, with little contamination in the immediate vicinity of the building.

H. Consideration of many conceivable causes for the incident and physical examination of the reactor facility and core have led to the following conclusions:

(1) The immediate cause of the incident was withdrawal of the central control blade. The displacement of the blade was consistent with the energy release determined from postincident studies.

(2) The absence of any evidence of an internal agent, such as a chemical reaction or explosion, together with the fact that only the central rod (and none of the four peripheral rods) was determined to be in a withdrawn position at the time of the explosion, makes it reasonably certain that the blade was withdrawn by an external agent.

(3) The only plausible hypothesis is that the central control blade was withdrawn manually, during the final phases of a maintenance operation of reassembly of the drive mechanism.

(4) No direct evidence is available as to how or why the central control blade was withdrawn to the position determined to exist at the time of the explosion. In particular, there is no direct evidence to indicate any kind of operational difficulty or other reason to deviate from the approved procedure for the reassembly operation in question.

September 14, 1962

REFERENCES [3]

1. TM 62-7-704, IDO 19311, Final Report of SL-1 Recovery Operation, May 1961 Through July 1962. Nuclear Materials & Propulsion Operation, Flight Propulsion Laboratory Department, General Electric. July 27, 1962.
2. IDO 19312, Letter to SL-1 Board of Investigation from W. H. Zinn, Vice President, Combustion Engineering, Inc., dated August 21, 1962, and Statement by Argonne National Laboratory for the Board of Investigation of the SL-1 Incident. This document is not signed or dated, but was received by the Board on August 21, 1962, from Mr. Meyer Novick as official representative of the Argonne National Laboratory.

[3] Copies of these reports are available for examination at the Commission's offices at 1717 H Street NW., Washington, D.C., and at the AEC Operations Office, Idaho Falls, Idaho. A limited number of copies is available from the Commission's Division of Public Information, Washington 25, D.C.

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APPENDIX 9

Radioisotope Licensees

LOCATION AND TYPE OF NEW AEC RADIOISOTOPE LICENSEES

December 1, 1961–November 30, 1962

[PP—Private Practice; IR—Industrial Radiography; CD—Civil Defense]

States	Medical institutions and physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutes	Other	Total
		PP			IR		CD			
Alaska	1	1		1		1				3
Alabama	4	1		4		15	14			23
Arizona				4	1	3	2			7
Arkansas	1			1		3	3			5
California	28	18	2	41	3	6	1		2	79
Colorado	5	3		4	1	8	6			17
Connecticut	5	2		12		5	4			22
Delaware	1			1		1	1			3
District of Columbia	7	5	1	3		4	1			15
Florida	20	12		6	2	19	17			45
Georgia	4	3	1	5		3	2			13
Hawaii	2	2	1	5		2	2			10
Idaho				2						2
Illinois	14	10	4	25	4	12	10	1		56
Indiana	5	4	2	4		15	15			26
Iowa	2	1	1	1		2	2			6
Kansas	4	1	2	6		18	18			30
Kentucky	3	2		2		5	5			10
Louisiana	5	4		3	2					8
Maine	3	1								3
Maryland	5	4	2	6		11	7		2	26
Massachusetts	11	8	2	9		3	2	2		27
Michigan	21	14	2	12	1	14	14			49
Minnesota	2	2	3	4	1	22	22			31
Mississippi	3	2	2							5
Missouri	6	3	1	8	1	8	8			23
Montana				1		2	1			3
Nebraska	5	4		4		6	5			15
Nevada	2	2		1		1	1			4
New Hampshire						1				1
New Jersey	15	8	1	18	3	7	6		1	42
New Mexico	1	1				9	5			10
New York	26	16	2	39	2	19	17			86
North Carolina	8	8		1		21	20			30
North Dakota						1	1			1
Ohio	9	7	3	24	4	6	6			42
Oklahoma	1		1	3	2	1	1		1	7
Oregon	3	1		3		16	14			22
Panama						1				1
Pennsylvania	17	9	1	23		12	10		1	54
Puerto Rico	3	2		2	1					5
Rhode Island						2	1			2
South Carolina	2	2		4		9	7			15
South Dakota	2	2		1		4	3			7
Tennessee	5	2	1	5	1	7	6			18
Texas	21	15	2	31	6	34	25			88

LOCATION AND TYPE OF NEW AEC RADIOISOTOPE LICENSEES—Continued

December 1, 1961–November 30, 1962—Continued

[PP—Private Practice; IR—Industrial Radiography; CD—Civil Defense]

States	Medical institutions and physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutes	Other	Total
		PP			IR		CD			
Utah				1		1	1			2
Vermont			1			2	2			3
Virginia	4	3	1	6		13	12	1		25
Washington	6	2	2	7	1	2	2			17
West Virginia	5	3		4		10	10			19
Wisconsin	6	4	3	7	2	2	1			18
Wyoming	1	1				5	4			6
Total	304	195	44	354	38	374	317	4	7	1,087

LOCATION AND TYPE OF AEC RADIOSCOPE LICENSEES

February 10, 1956–November 30, 1962

[PP—Private Practice; IR—Industrial Radiography; CD—Civil Defense]

States	Medical institutions and physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutes	Other	Total
		PP			IR		CD			
Alaska	3	2	1	1	0	10	5	0	0	15
Alabama	43	24	4	21	8	29	21	1	0	98
Arizona	19	12	3	11	1	19	16	0	1	53
Arkansas	22	13	1	8	0	5	5	0	0	36
California	27	4	3	69	14	28	0	2	0	129
Colorado	36	13	7	26	4	37	29	1	3	110
Connecticut	41	19	6	55	10	20	15	1	1	124
Delaware	5	1	1	12	1	6	6	0	0	24
District of Columbia	33	16	5	8	2	34	17	2	2	84
Florida	99	62	5	26	9	47	39	0	1	178
Georgia	47	24	6	16	6	20	15	0	0	89
Hawaii	17	13	2	12	2	7	4	1	0	39
Idaho	6	3	2	5	3	2	1	0	0	15
Illinois	142	49	11	144	19	54	45	4	3	358
Indiana	62	32	11	50	14	31	31	0	3	157
Iowa	50	26	9	13	4	25	24	0	1	98
Kansas	30	11	5	21	5	35	34	0	0	91
Kentucky	7	0	0	0	0	2	0	0	0	.9
Louisiana	42	19	6	34	16	11	9	2	1	96
Maine	20	7	2	5	1	4	3	0	1	32
Maryland	40	17	8	28	7	43	26	2	3	124
Massachusetts	87	32	22	110	13	24	19	8	3	254
Michigan	123	59	13	64	16	59	51	2	2	263
Minnesota	46	21	16	25	5	107	106	0	0	194
Mississippi	1	0	0	1	1	1	0	0	0	3
Missouri	86	41	7	37	9	35	33	0	1	166
Montana	13	4	3	4	0	4	2	0	0	24
Nebraska	25	13	2	7	1	32	31	0	1	67
Nevada	9	6	1	6	1	6	5	0	0	22
New Hampshire	12	2	4	7	2	11	9	0	0	34
New Jersey	117	62	3	147	24	35	28	2	2	306
New Mexico	19	11	6	15	0	16	7	0	0	56
New York	10	1	5	66	6	13	1	0	0	94
North Carolina	60	37	7	18	0	63	58	0	1	149
North Dakota	8	5	2	2	1	8	7	0	0	20
Ohio	152	76	16	139	38	63	52	3	2	375
Oklahoma	44	29	5	33	12	14	12	1	1	98
Oregon	34	20	7	12	7	32	27	1	0	86
Panama	1	0	0	0	0	1	0	0	0	2
Pennsylvania	151	54	20	174	49	128	112	6	5	484
Puerto Rico	12	6	3	3	1	2	2	0	0	20
Rhode Island	7	1	3	7	1	6	5	0	0	23
South Carolina	18	12	3	9	3	21	16	0	0	51
South Dakota	19	11	3	3	0	15	14	0	0	40
Tennessee	46	21	6	34	5	19	16	0	1	106
Texas	189	127	20	135	37	75	59	4	1	424
Utah	9	1	4	17	3	16	12	0	0	46
Vermont	11	7	3	2	0	3	3	0	0	19
Virginia	39	15	8	39	7	30	20	1	1	118
Washington	48	27	10	27	9	37	33	1	0	123
West Virginia	28	15	2	21	2	40	37	0	0	91
Wisconsin	63	23	9	41	18	7	4	3	1	124
Wyoming	5	2	1	7	1	18	15	0	2	33
Total	2,283	1,108	312	1,777	398	1,410	1,141	48	44	5,874

APPENDIX 10

Operable Foreign Reactors and Assemblies Subject to U.S. Safeguards

as of December 31, 1962

REACTORS AND CRITICAL ASSEMBLIES IN 22 COUNTRIES

Country	Facility name	Type	Site	Fuel enrichment—%	Thermal power	Reason for safeguards			Maximum inspection frequency	Inspections
						U.S. fuel	U.S. built	U.S. heavy water		
Argentina	RA-1	Argonaut	Buenos Aires	20	10 KW	X			1/yr	2/58, 12/60, 12/61
Australia	HIFAR	Dido	Lucas Hgts	90	10 MW			X		3/60, 4/61, 5/62
	MOATA	Argonaut	Lucas Hgts	90	10 MW	X	X		2/yr	3/60, 4/61, 5/62
Austria	ASTRA	Pool	Seibersdorf	90	12 MW	X	X		2/yr	11/61, 7/62
		TRIGA Mk II	Vienna	20	100 KW	X	X		Nominal	7/62
Belgium	BR-2	MTR	Mol	90	50 MW	X			8/yr	1/60, 3/61, 1/62, 10/62
	BR-3								2/yr	1/62, 10/62
Brazil	IEAR-1	Pool	Sao Paulo	20	5 MW	X	X		1/yr	2/58, 12/60, 12/61
		TRIGA Mk II	Belo Horizonte	20	30 KW	X	X		Nominal	12/60
China, Rep. of	CRR	Pool	Tsing Hua Univ	20	1 MW	X	X		1/yr	4/61, 5/62
Denmark	DR-1	Aq. Homo. L-55	Risø	20	500 W	X	X		Nominal	11/57, 5/59
	DR-2	Pool-Tank	Risø	90	5 MW	X	X		3/yr	5/59, 5/60, 5/61, 6/62
	DR-3	Pluto	Risø	90	10 MW			X	1/yr	5/59, 5/60, 5/61, 6/62
France	EL-3	Tank D_2O	Saclay	1.6	15 MW	X			1/yr	10/58, 1/60, 3/61, 10/62
	ALIZE	Crit. Facility	Saclay	3.5/90	0	X			4/yr	10/58, 1/60, 3/61
	PROSERPINE	Aq. Homo. Pu & U	Saclay	1.5	1 W	X			Nominal	3/61, 10/62

Operable Foreign Reactors and Assemblies Subject to U.S. Safeguards—Continued

Country	Facility name	Type	Site	Fuel enrichment—%	Thermal power	Reason for safeguards			Maximum inspection frequency	Inspections
						U.S. fuel	U.S. built	U.S. heavy water		
France—Continued	AQUILON	Res. Reactor	Saclay	Natural	1 W			X	Nominal	3/61, 10/62
	MELUSINE	Pool	Grenoble	20	1 MW	X			2/yr	10/58, 1/60, 3/61, 1/62, 10/62
	TRITON I & II	Pool	Fontenay	20	1 MW	X			1/yr	1/60, 3/61, 10/62
	MINERVE	Pool	Fontenay	20	100 W	X			2/yr	1/60, 3/61, 1/62, 10/62
	PEGGY	Pool	Cadarache	20	0	X			1/yr	3/61, 10/62
	ULYSSE	Argonaut	Saclay	90	100 KW	X			2/yr	1/62, 10/62
	AZUR	Crit. Facility	Cadarache	90	0	X			1/yr	
	RUBEOLE	Crit. Facility	Saclay	1. 5/3	0	X			Nominal	10/58, 1/60, 10/62
West Germany	FRM	Pool	Munich	20	1 MW	X	X		1/yr	10/58, 1/60, 3/61, 10/62
	SAR	Argonaut	Munich	20	10 KW	X		X	1/yr	1/60, 3/61, 10/62
	FR-2	Tank Nat U D_2O	Karlsruhe	Natural	12 MW			X	1/yr	1/60, 3/61, 10/62
	FRF	Aq. Homo	Frankfurt	20	50 KW	X	X		Nominal	10/58, 1/60
	FRB	Aq. Homo	W. Berlin	20	50 KW	X	X		Nominal	10/58, 1/60
	FRG	Pool	Hamburg	20	5 MW	X	X		1/yr	10/58, 1/60, 3/61, 10/62
	RWE	BWR-Power	Kahl am Main	2.5	60 MW	X	X		3/yr	3/61, 1/62, 10/62
	AEG	Argonaut	Grosswelzheim	20	10 KW	X	X		1/yr	3/61, 10/62
	SUR-100	Solid Homo	Munich	20	10 W	X			Nominal	10/62
	DIDO-JULICH	Dido	Julich	80	10 MW			X	1/yr	10/62
		TRIGA Mk II	Mainz	20	30 KW	X	X		Nominal	
	AZPRR	Argonaut	Karlsruhe	20	0	X			1/yr	10/62
Greece	CRR	Pool	Athens	20	1 MW	X	X		1/yr	8/61, 9/62
India	ZERLINA	Crit. Assem	Trombay	Natural	0			X	Nominal	3/62
Israel	IRR	Pool	Rehoboth	90	5 MW	X	X		2/yr	6/60, 8/61, 3/62, 9/62
Italy	RS-1	Pool	Saluggia	20	5MW	X	X		1/yr	5/59, 5/60, 6/61, 9/62
	ISPRA-I & II	CP-5	Ispra	20/90	5 MW	X	X	X	2/yr	5/59, 6/60, 8/61, 9/62

		Aq. Homo. L-54	Milan	20	50 KW	X	X		Nominal	6/59, 5/60
	CNRN	TRIGA Mk II	Rome	20	100 KW	X	X		Nominal	8/61
		AGN-201	Palermo	20	20 W	X	X		Nominal	8/61
	RB-1	Mod. Argonaut	Bologna	20	10 W	X			1/yr	9/62
Japan	JRR-1	Aq. Homo	Tokai-Mura	20	50 KW	X	X		1/yr	8/57, 3/60, 5/62
	JRR-2	CP-5	Tokai-Mura	20/90	10 MW	X	X	X	1/yr	30/60, 4/61, 5/62
		Semi-Homo. C.A	Tokai-Mura	20	0	X			1/yr	3/60, 4/61, 5/62
		Aq. Homo. C.A	Tokai-Mura	20	0	X			Nominal	5/62
	KINKI	UTR	Osaka	90	10 W	X	X		1/yr	5/62
	RIKKYO	TRIGA Mk II	Tokyo	20	100 KW	X	X		Nominal	5/62
	TOSHIBA	Pool	Tokyo	20	100 KW	X			Nominal	5/62
	HITACHI	Pool	Tokyo	10	100 KW	X			1/yr	5/62
Korea	KRR	TRIGA II	Seoul	20	100 KW	X	X		Nominal	4/61
Netherlands	LFR	Argonaut	Petten	90	100 KW	X			1/yr	5/61, 6/62
	HFR	ORR	Petten	90	20 MW	X	X		2/yr	6/59, 5/61, 6/62
Norway	HBWR	Boiling Water	Halden	1.5	10 MW	X		X	1/yr	5/59, 5/60, 5/61, 6/61, 6/62
Portugal		Pool	Sacavem	20	1 MW	X	X		1/yr	10/61, 9/62
Spain	JEN-1	Pool	Moncloa	20	3 MW	X	X		1/yr	6/59, 6/60, 10/61, 9/62
	ARGOS	Argonaut	Barcelona	20	10 KW	X			1/yr	9/62
	ARB-1	Argonaut	Bilbao	20	0	X				9/62
Sweden	R-2-0	Pool	Studsvik	90	100 KW	X			1/yr	5/61, 6/62
	R-2	ORR	Studsvik	90	30 MW	X	X		2/yr	5/60, 5/61, 6/62
Switzerland	SAPHIRE	Pool	Wuerenligen	20	1 MW	X	X		1/yr	6/59, 6/60, 10/61, 6/62
	ALADIN	AGN-201	Geneva	20	20 W	X	X		Nominal	6/59
		AGN-211	Basel	90	1 KW	X	X		1/yr	6/59
	Diorit	Tank	Wuerenligen	Natural	20 MW			X	1/yr	6/62
Turkey	CEKMECE	Pool	Istanbul	90	1 MW	X	X		1/yr	8/61, 9/62

APPENDIX 11

Foreign Research Reactor Grants

May 30, 1956—December 31, 1962

GRANTS PAID—18

Country	Type	Power (thermal)	Manufacturer	Estimated Project Cost (millions)	Year Grant Paid
Austria, Vienna	Tank	5 MW [1]	American Machine & Foundry	$4.0	1960
Belgium, Mol	Tank	25 MW [2]	Centre d'Etudes de l'Energie Nucleaire.	10.01	1961
Brazil, Sao Paulo	Pool	5 MW	Babcock and Wilcox	1.3	1958
China, Hsinchius	Pool	1 MW	International General Electric	1.0	1961
Denmark, Risoe	Tank	5 MW	Foster-Wheeler	1.4	1960
Greece, Aghai Paraskeri	Pool	1 MW	American Machine & Foundry	1.3	1961
Israel, Nahal Sorek	Pool	1 MW	American Machine & Foundry	1.4	1961
Italy, Ispra	Tank	5 MW	American Car and Foundry	3.6	1959
Japan, Tokai-Mura	Tank	10 MW	American Machine & Foundry	1.5	1960
Korea, Alyang	Tank	100 KW	General Atomic	1.1	1962
Norway, Kjeller	Pool	10 KW	Norstom	0.8	1961
Portugal, Lisbon	Pool	1 MW	American Machine & Foundry	1.0	1961
Spain, Madrid	Pool	3 MW	International General Electric	1.0	1958
Sweden, Studsvik	Tank	30 MW	American Car and Foundry	4.3	1962
Thailand	Pool	1 MW	Curtis-Wright	0.82	1962
Turkey, Istanbul	Pool	1 MW	American Machine and Foundry	2.88	1962
Venezuela, Caracas	Pool	3 MW	International General Electric	5.0	1960
West Germany, Munich	Pool	1 MW	American Machine and Foundry	3.1	1958

GRANTS COMMITTED—8

					Year grant committed
Argentina, Ezeiza	Tank	5 MW	Argentine National Atomic Energy Commission.		1962
Colombia, Bogota	Tank	10 KW	American Machine and Foundry		1962
Indonesia, Bandung	Tank	100 KW	General Atomic	0.8	1961
Iran, Tehran	Pool	5 MW	American Machine and Foundry	4.8	1962
Netherlands, Petten	Tank	20 MW	American Car and Foundry	3.9	1956
Pakistan, Rawalpindi	Pool	5 MW	American Machine and Foundry	3.5	1960
Viet Nam, Dalat	Tank	100 MW	General Atomic	0.75	1959
Yugoslavia, Ljubljana	Tank	100 KW	General Atomic		1960

[1] Convertible to 12 MW.
[2] Convertible to 50 MW.

APPENDIX 12

Film Libraries

The domestic libraries are located at the following Commission offices and cover requests from the following States:

Washington, D.C	Maryland, Virginia, West Virginia, District of Columbia, Delaware and Canada.
New York, N. Y	New York, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Pennsylvania and New Jersey.
Aiken, S.C	Alabama, Florida, North Carolina, South Carolina and Georgia.
Idaho Falls, Idaho	Montana, Utah and Idaho.
Berkeley, Calif	California, Hawaii and Nevada.
Grand Junction, Colo	Colorado, Wyoming, Kansas and Nebraska.
Argonne, Ill	North Dakota, South Dakota, Missouri, Iowa, Ohio, Indiana, Michigan, Minnesota, Wisconsin and Illinois.
Oak Ridge, Tenn	Kentucky, Mississippi, Arkansas, Louisiana and Tennessee.
Albuquerque, N. Mex	Arizona, New Mexico, Texas and Oklahoma.
Richland, Wash	Washington, Oregon and Alaska.

APPENDIX 13

AEC Depository Libraries

Collections of Commission reports are maintained in the libraries of the organizations listed below for reference use by the general public. Facilities for making photocopies are available. The Commission also makes available through these libraries atomic energy reports of countries other than the United States that are abstracted in *Nuclear Science Abstracts*.

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- Los Angeles, University of California
- Menlo Park, Stanford Research Institute
- San Diego, Public Library

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- Boulder, University of Colorado
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CONNECTICUT
- New Haven, Yale University

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- Washington, Library of Congress

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- Baton Rouge, Louisiana State University
- New Orleans, Tulane University

MARYLAND
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- Cambridge, Harvard University
- Cambridge, Massachusetts Institute of Technology

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- Ann Arbor, University of Michigan
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GREECE
Athens, Greek Atomic Energy Commission

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Guatemala, Comisión Nacional de Energía Nuclear

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APPENDIX 14

LICENSE APPLICATIONS FILED AND ACTIONS TAKEN

SUMMARY OF LICENSING ACTIONS

FACILITIES [a]	PERMITS AND LICENSES ISSUED						Permits and Licenses in effect as of Nov. 30, 1962
	Sept. 1, 1954 to Dec. 31, 1957	Jan. 1, 1958 to Dec. 31, 1958	Jan. 1, 1959 to Dec. 31, 1959	Jan. 1, 1960 to Dec. 31, 1960	Jan. 1, 1961 to Dec. 31, 1961	Jan. 1, 1962 to Nov. 30, 1962	
Power Reactors (Part 50)							
Construction permits	5	0	0	5	1	1	4
Construction permit amendments and orders	1	4	5	2	5	5	
Licenses to operate	1	0	1	1	1	5	8
License amendments, authorizations and orders	1	7	7	7	23	42	
Power Reactors (Part 115)							
Construction Authorizations	0	0	1	3	0	0	1
Operating Authorizations	0	0	0	0	0	3	3
Operating Authorization amendments						4	
Test Reactors							
Construction permits	1	2	0	0	0	0	0
Construction permit amendments and orders	1	0	1	1	1	0	
Licenses to operate	0	0	2	0	1	0	3
License amendments and authorizations	0	0	3	6	6	5	
Research Reactors							
Construction permits	[b] 20	[c] 11	[d] 15	14	[e] 8	4	[f] 11
Construction permit amendments and orders	5	9	15	12	10	11	
Licenses to operate (including acquire and operate)	28	19	9	11	9	6	60
License amendments	16	17	34	29	79	48	
Reactor Exports							
Research Reactor Licenses	16	5	11	3	2	2	(g)
Test Reactor Licenses	0	2	0	0	1	0	(g)
Power Reactor Licenses	0	1	1	0	1	2	(g)
License amendments	6	14	10	14	14	7	

Critical Experiment Facilities							
Construction permits	10	4	1	2	1	1	1
Construction permit amendments and orders	2	2	1	3	3	0	----
Licenses to operate	6	5	3	2	1	1	15
License amendments	1	10	16	14	13	8	----
Production Facilities							
Construction permits	0	0	0	0	1	0	0
Construction permit amendments and orders	0	0	0	0	2	1	----
Licenses to operate	0	0	0	0	0	0	0
Import licenses	0	0	0	1	0	0	----
Operator licenses	148	215	176	222	216	282	852
Operator license amendments and renewals	21	67	81	141	174	236	----
Operator license denials	1	4	11	54	24	33	----
Special Nuclear Material licenses	151	115	73	85	127	101	454
SNM license amendments and renewals	92	156	194	249	288	292	----
SNM license denials	1	0	1	1	3	0	----
Source Material licenses issued or renewed	4,541	1,303	1,168	1,061	517	153	460
Source Material export licenses	2,456	676	721	696	228	120	(g)
Source Material license denials	5	1	0	2	2	2	----
Byproduct Material licenses (domestic use)	[h] 3,172	3,014	2,526	1,688	1,460	1,376	7,898
Byproduct Material license amendments	[h] 589	2,338	3,101	4,837	5,712	5,568	----

[a] Applications to construct and operate are filed simultaneously; conversions from construction permits to licenses to operate are made upon satisfactory completion of construction.

[b] Permits authorize construction of 36 reactors and modification of 2 reactors.

[c] Permits authorize construction of 38 reactors.

[d] Permits authorize construction of 13 reactors and modification of 2 reactors.

[e] Permits authorize construction of 6 reactors and relocation of 2 reactors.

[f] Permits authorize construction of 18 reactors and modification of 1 reactor.

[g] Export licenses terminate upon completion of shipment.

[h] Figures cover the period of Feb. 10, 1956 thru Dec. 31, 1956.

Facility License Applications [a]

POWER REACTORS

Applicant and location of facility	Description of facility	Date original application filed	Status
Carolinas-Virginia Nuclear Power Associates, Inc., Parr, S.C.	17,000-kilowatt (electrical) vertical pressure tube, heavy water moderated and cooled reactor.	July 9, 1959	Construction permit issued May 4, 1960; provisional operating license issued Nov. 27, 1962.
Commonwealth Edison Co., Dresden Station, Grundy County, Ill.	180,000-kilowatt dual cycle, boiling water reactor.	Apr. 1, 1955	Construction permit issued May 4, 1956; 45-day limited license for 1-megawatt (thermal) operation issued Sept. 28, 1959; amended Nov. 5, 1959 to expire Dec. 10, 1959; amended Nov. 16, 1959 for 315-megawatt (thermal) operation after Dec. 10, 1959; amended June 2, 1960 for operation at power levels up to, but not in excess of, or at steady state power level of 630 megawatts (thermal); amended Oct. 14, 1960 for steady state operation at 630 megawatts (thermal); reactor shut down in Nov. 1960 due to control rod difficulties; 100-kilowatt operation authorized Mar. 31, 1961; 630-megawatt (thermal) operation authorized May 27, 1961; license amended June 9, 1961 and Aug. 3, 1962 to include revised technical specifications; license amended Sept. 4, 1962 to authorize steady state operation at power levels not in excess of 700 megawatts (thermal).
Consolidated Edison Co., Westchester County, N.Y.	163,000-kilowatt (electrical) pressurized water (plus 112,000 kw of conventional superheater capacity).	Mar. 22, 1955 [b]	Construction permit issued May 4, 1956; amended Aug. 4, 1961, to approve final design of reactor; provisional operating license issued Mar. 26, 1962; authorized on May 16, 1962, to load first core and to proceed to steady state power level of 585 thermal megawatts subject to provisions of license.
Consolidated Edison Co. Ravenswood, Borough of Queens, New York City.	1,000,000-kilowatt (electrical) single cycle, pressurized water, with two oil-fired superheaters.	Pending.	
Consumers Power Co., Big Rock Point, Charlevoix County, Mich.	75,000-kilowatt (electrical) high power density, single cycle, boiling water reactor.	Jan. 18, 1960	Construction permit issued May 31, 1960; provisional operating license issued Aug. 30, 1962; loading of first core and operation at thermal power levels up to one megawatt authorized Sept. 26, 1962; operation at thermal power levels to 157 megawatts authorized Nov. 1, 1962.

See footnotes at end of table.

FACILITY LICENSE APPLICATIONS [a]—Continued

POWER REACTORS—Continued

Applicant and location of facility	Description of facility	Date original application filed	Status
Pacific Gas and Electric Co., Humboldt Bay Power Plant, Eureka, Calif.	50,000-kilowatt (electrical) single cycle boiling water reactor.	Apr. 30, 1959	Construction permit issued Nov. 9, 1960; provisional operating license issued Aug. 28, 1962.
Pacific Gas & Electric Co., Bodega Bay Atomic Park Unit No. 1, Bodega Head, Sonoma County, Calif.	325,000 kilowotts (eletrical), single cycle, forced circulation, boiling water reactor.	Pending.	
Philadelphia Electric Co., Peach Bottom, York County, Pa.	40,000-kilowatt (electrical) helium - cooled graphite moderated, developmental reactor.	July 25, 1960	Construction permit issued Feb. 23, 1962.
Power Reactor Development Co., Lagoona Beach, Mich.	60,000-kilowatt (electrical) fast breeder reactor.	Jan. 7, 1956	Construction permit issued Aug. 4, 1956; hearing to consider issuance of provisional operating license scheduled for January 3, 1963.
Saxton Nuclear Experimental Corp., Saxton, Pa.	20,000-kilowatt (thermal) pressurized light water reactor.	July 24, 1959	Construction permit issued Feb. 11, 1960; provisional operating license issued Nov. 15, 1961; first core loading and operation with reactor head off at power levels to 200 kilowatts (thermal) authorized Apr. 3, 1962; steady state operation at power levels to 20 megawatts (thermal) authorized Aug. 15, 1962; conduct of Phase I of Research and Development Program at thermal power levels to 23.5 megawatts authorized Oct. 9, 1962.
Yankee Atomic Electric Co., Rowe, Mass.	134,000-kilowatt (electrical) pressurized light water reactor.	July 9, 1956	Construction permit issued Nov. 4, 1957; limited license for 5-megawatt (thermal) operation issued July 9, 1960; amended July 29, 1960, for operation at power levels not in excess of 392 megawatts (thermal); amended June 23, 1961, for full term license authorizing operation at power levels to 485 megawatts (thermal); amended Oct. 11, 1962, authorizing steady state operation at 540 megawatts. (thermal).
City of Piqua and North American Aviation, Inc., Piqua, Ohio.	45.5-megawatt (thermal) organic cooled and moderated reactor (11.4 Mwe).	----------	Construction authorization issued Jan. 7, 1960; Provisional Operating Authorization issued Aug. 23, 1962.
Consumers Public Power District and North American Aviation, Inc., Hallam, Nebr.	256-megawatt (thermal) sodium cooled, graphite moderated reactor (75 Mwe).	----------	Construction authorization issued June 6, 1960; Provisional Operating Authorization issued Jan. 2, 1962, for performance of "Dry Critical Experiments"; amended Aug. 9, 1962, for conduct of "Wet Critical Experiments" and operations not in excess of 15% of full power.

See footnotes at end of table.

668848—63——36

FACILITY LICENSE APPLICATIONS [a]—Continued

POWER REACTORS—Continued

Applicant and location of facility	Description of facility	Date original application filed	Status
Dairyland Power Cooperative and Allis-Chalmers Mfg. Co., Genoa Station, Vernon County, Wis.	50-megawatt (electrical) direct cycle, forced circulation, boiling water reactor.	Nov. 5, 1962	Pending.
Rural Cooperative Power Ass'n. and Allis-Chalmers Mfg. Co., Elk River, Minn.	22-megawatt (electrical) indirect cycle, natural circulation, boiling water reactor.	----------	Construction authorization issued Dec. 18, 1959; Provisional Operating Authorization issued Nov. 6, 1962; core loading and operation at steady state power levels to 58.2 thermal megawatts authorized Nov. 10, 1962.
TEST REACTORS			
The Babcock & Wilcox Co., Lynchburg, Va.	6-megawatt pool-type, light water cooled and moderated reactor.	July 12, 1962	Hearing to consider issuance of construction permit held Dec 10, 1962.
General Electric Co., Alameda County, Calif.	33,000-kilowatt pressurized water reactor.	June 14, 1957	Construction permit issued Mar. 11, 1958; licenses issued, for criticality tests Dec. 22, 1958; for test reactor operation Jan. 7, 1959; amended Mar. 11, 1960 to authorize changes in boiling water loop and operation of the loop; operation with modified pressurized water loop authorized Feb. 19, 1962.
National Aeronautics and Space Administration, Sandusky, Ohio.	60,000-kilowatt pressurized water reactor.	Aug. 20, 1956	Construction permit issued July 21, 1958; provisional license issued Mar. 14, 1961; core loading and operation at thermal power levels to one kilowatt authorized June 12, 1961; operation at power levels past level of one kilowatt and under 100 kilowatts, authorized May 1, 1962; operation at steady state power levels to 60 megawatts (thermal) authorized Aug. 23, 1962.
RESEARCH REACTORS			
Armed Forces Radiobiology Research Institute, National Naval Medical Center, Bethesda, Md.	TRIGA reactor, 100-kilowatt steady state, multimegawatt pulses.	July 21, 1960	Construction permit issued Nov. 8, 1960; operating license issued June 26, 1962.

See footnotes at end of table.

FACILITY LICENSE APPLICATIONS [a]—Continued

RESEARCH REACTORS—Continued

Applicant and location of facility	Description of facility	Date original application filed	Status
The Babcock & Wilcox Co., Lynchburg, Va.	10-kilowatt pool-type reactor (Lynchburg Pool Reactor).	Mar. 28, 1958	Construction permit issued Sept. 4, 1958; license issued Sept. 5, 1958 for steady state operations at 10 kilowatts and intermittent operation at power levels to 200 kilowatts; amended May 25, 1961 for operation at power levels to 450 thermal kilowatts; construction permit authorizing modification of Lynchburg Pool Reactor for 1-megawatt operation issued Sept. 28, 1962; license amended Nov. 15, 1962 to permit such operations.
Cornell University, Ithaca, N.Y.	10-kilowatt dual core, pool-type reactor (application resubmitted to cover 10-watt pool-type reactor designated the Zero Power Reactor).	Feb. 21, 1958 Jan. 4, 1960	Construction permit issued Nov. 21, 1958; amended Apr. 15, 1960 to authorize construction of Zero Power Reactor; operating license issued Dec. 11, 1962.
Do	10-kilowatt TRIGA reactor.	Jan. 4, 1960	Construction permit issued June 29, 1960; operating license issued Jan. 11, 1962.
Kansas State University of Agriculture and Applied Science, Manhattan, Kans.	100-kilowatt TRIGA Mark II reactor.	Apr. 12, 1961	Construction permit issued Aug. 15, 1961; operating license issued Oct. 16, 1962.
Lockheed Aircraft Corp. and U.S. Air Force Dawsonville, Ga.	1-Megawatt Radiation Effects Reactor (RER).	Mar. 2, 1962	License issued July 20, 1962 authorizing Lockheed to operate and the Air Force to possess the RER.
Manhattan College Corp., New York, N.Y.	10-watt pool-type reactor.	June 27, 1962	Pending.
Pennsylvania State University, University Park, Pa.	100-kilowatt pool-type reactor.	May 9, 1955	License issued July 8, 1955; amended for 200 kw operation May 13, 1960; construction permit issued Oct. 2, 1962 authorizing enlargement of reactor bay.
Purdue University, West Lafayette, Ind.	1-kilowatt pool-type reactor.	Feb. 1, 1961	Construction permit issued Aug. 7, 1961; operating license issued Aug. 16, 1962.
Rhode Island and Providence Plantations Atomic Energy Commission, Fort Kearney, R.I.	1-megawatt pool-type reactor.	Dec. 26, 1961	Construction permit issued Aug. 27, 1962.
University of Nevada	10-watt laboratory reactor (Atomics International Model L-77).	Sept. 17, 1962	Pending.
University of Texas, Austin, Tex.	10-kilowatt TRIGA Mark I reactor.	Nov. 8, 1961	Construction permit issued Feb. 12, 1962.
Walter Reed Army Institute of Research, Washington, D.C.	50-kilowatt homogeneous solution-type reactor (Atomics International Model L-54).	May 20, 1959	Construction permit issued Jan. 6, 1960; operating license issued Aug. 17, 1962.

See footnotes at end of table.

FACILITY LICENSE APPLICATIONS [a]—Continued

CRITICAL EXPERIMENT FACILITIES

Applicant and location of facility	Description of facility	Date original application filed	Status
The Babcock & Wilcox Co., Lynchburg, Va.	Critical experiments for Advanced Test Reactor (ATRCE).	Sept. 15, 1961	Construction permit issued Dec. 19, 1961; operating license issued May 14, 1962.
General Electric Co., Alameda County, Calif.	Mixed Spectrum Critical Assembly.	Oct. 9, 1962	Pending.
National Aeronautics and Space Administration, Cleveland, Ohio.	10-watt critical facility (ZPR-II).	Sept. 28, 1961	Construction permit issued Apr. 12, 1962.
Lockheed Aircraft Corp. and U.S. Air Force, Dawsonville, Ga.	Critical Experiment Reactor (CER).	Mar. 2, 1962 Mar. 19, 1962	Pending.

PRODUCTION FACILITIES

Martin-Marietta Corp., Quehanna, Pa.	Chemical Separation Facility.	Jan. 25, 1961	Construction permit issued Mar. 1, 1961; application subsequently amended to delete operations with Curium 242 and its contaminants, including special nuclear material.
Nuclear Fuel Services, Inc., Town of Ashford, Cattaraugus County, N.Y.	Fuel Processing Plant...	July 26, 1962	Pending.

EXPORT LICENSES

American Radiator & Standard Sanitary Corp., Mountain View, Calif.	100-kilowatt Model UTR-100 research reactor for export to Scottish Research Reactor Center, East Kilbride, Scotland.	June 4, 1962	License issued Nov. 8, 1962.
American Machine & Foundry Co., AMF Atomics Division, Greenwich, Conn.	5-megawatt pool-type research reactor for export to the Pakistan Atomic Energy Commission, Rawalpindi, Pakistan.	Aug. 21, 1961	License issued Apr. 23, 1962.
General Electric Co., Intl. General Electric Co. Division, New York, N.Y.	12.5-megawatt (electrical) boiling water power reactor for export to the Japan Atomic Energy Research Institute, Tokyo, Japan.	Jan. 17, 1962	License issued Mar. 16, 1962.
Westinghouse Electric Co., Div. of Westinghouse Electric Corp., New York, N.Y.	165-megawatt (electrical) pressurized light water power reactor for export to Societa Elettronucleare Italiana (SELNI), Milan, Italy.	Feb. 5, 1962	License issued June 14, 1962.

[a] For other facility applications and licensing actions in previous years see Appendix 8 of 1961 Annual Report to Congress.

[b] Date of application.

APPENDIX 15

Environmental Contamination From Nuclear Explosives

FALLOUT FROM NUCLEAR EXPLOSIVE TEST AT THE NEVADA TEST SITE

Since the resumption of nuclear weapons tests in Nevada on September 15, 1961, the U.S. Atomic Energy Commission announced the detonation of 56 nuclear devices (through December 31, 1962) in underground chambers which were designed to contain the radioactivity and to prevent the release of radioactive material off the test site. In addition, five devices were detonated either slightly above ground or at a shallow depth underground. These five devices were detonated under conditions that would minimize exposures to off-site areas.

In addition, the AEC conducted two Plowshare program nuclear experiments to develop peaceful uses for nuclear explosives. Project Sedan, was a cratering experiment on July 6, 1962, at the Nevada Test Site (NTS). (The other experiment was Project Gnome, a deep underground experiment near Carlsbad, N. Mex., on December 10, 1961.)

By agreement with the AEC, off-site radiological monitoring near the NTS is conducted by the U.S. Public Health Service. This off-site area extends to a radius of approximately 300 miles.

The physical characteristics and relative amounts of various radioactive isotopes released by these tests vary somewhat from those of the past tests at NTS. In test series prior to 1961, nuclear devices were airdropped or were detonated on steel towers, balloons, or in uncovered shallow holes; thus, fallout particles contained many kinds of debris in addition to the radioactivity. Induced activity in the debris contributed little to the total radioactivity in the fallout. Although there have been four surface shots or near-surface detonations, plus one cratering shot giving off-site fallout resembling that from similar past tests, the major portion of the activity in the remainder of the series has been contained on-site or underground.

Some of the underground test detonations since September 15, 1961, vented small amounts of gaseous activity to the atmosphere. The nature of these releases of gaseous material is such that the clouds formed do not rise to altitudes such as those released from the surface or near surface detonations, but linger near the surface and are acted upon by the lower tropospheric and surface winds. Normally, these clouds are so dispersed by the time they reach off-site populated areas that they are difficult to detect with portable monitoring equipment. However, in a few events, clouds have passed over areas where people were located; hence, there have been some off-site radiation exposures. These exposures are recorded on film badges furnished to these people by AEC for documentation purposes.

Because of the gaseous nature and rapid movement of these clouds, stringent requirements are placed on the off-site monitors who must intercept the clouds and record radiation intensities during passage of the clouds. Airborne monitors locate and track the radioactivity and direct the mobile ground monitors into the path of the clouds. Unless there is a continuous recording air or background radiation instrument or a mobile ground monitor in an area when a radioactive cloud passes, passage of the cloud can be estimated only by predicting the cloud trajectory to determine whether the cloud has passed a specific

area. There is generally little radioactivity deposited on the ground from these clouds. Records of cloud passage are obtained by mobile ground monitors in addition to routine monitoring of large off-site areas near the test site.

INDIVIDUAL EXPOSURES OFF-SITE

More than 260 persons in the off-site area surrounding the Nevada Test Site have been issued film badges since September 1961. Each individual has been informed of his exposure record. Table I summarizes the highest exposures received by off-site individuals from September 15, 1961, until about September 4, 1962. These records have been corrected for natural background radiation exposure, which is approximately 0.5 mr/day for the general area. Table II lists the locations and number of people wearing film badges that recorded no identifiable radiation exposure above natural background.

Milk

Milk collections have been made in the vicinity of NTS, and the samples analyzed by the U.S. Public Health Service, under an agreement with the U.S. Atomic Energy Commission. Tables, IV, V, VI, and VII present the highest concentrations of iodine 131 detected in milk during the indicated time periods.

In July 1962, the wind trajectories of radioactive clouds from five nuclear tests passed over the Salt Lake City area. Three of these clouds are known to have deposited residual fallout activity in this area. Iodine 131 (I–131) was detected in milk supplies for a short period of time. The tables show that while the peak value of I–131 in milk in the Salt Lake City area was relatively high, the average levels over a period of time were too low to constitute a significant health hazard. For example, the U.S. Public Health Service milk monitoring station at Salt Lake City recorded a yearly average of 102 micromicrocuries of I–131 per liter of milk. A daily intake of 102 micromicrocuries of I–131 might result in a one-half roentgen exposure to the thyroid of young children and lesser amounts to adult thyroids.

Gross Beta Air Activity

At the present time, there are 28 permanent air sampling stations in operation surrounding NTS. The data recorded by these air samplers are used by the off-site monitoring group as an indicator of the presence of airborne radioactivity in that area. These data indicate the presence of radioactivity and the need for further monitoring but are of no direct value in assessing radiation doses. For purposes of illustration, the ten highest levels found in the area are listed in Table VIII.

Isotopic Air Results

The relative quantities of various isotopes in air are obtained from isotopic analysis of samples taken by prefilters and charcoal cartridges. Some of the highest values determined for I–131, I–133, and I–135 are shown in Table IX.

Water Supplies

Gross beta water monitoring is conducted for water supplies used by people in the off-site area around NTS. All sources monitored are subsurface supplies, except Lake Mead. There are no known surface water supplies for human use in the nearby off-site area. The highest levels of gross beta activity in water

supplies during the period of October 1961 to October 1962 are listed in Table X. For comparison, there have been selected some data from the U.S. Public Health Service on radioactivity in raw surface water in the United States.

Isotopic analysis was conducted on many of these NTS samples, and the results show that levels of cesium 137, barium 140, zirconium 95, ruthenium 103, cerium 141, cerium 144, and iodine 131 were below the levels of detection. Levels of strontium 89 and strontium 90 were less than 5 $\mu\mu c$ and 1 $\mu\mu c$ per liter, respectively.

TABLE I.—HIGHEST EXPOSURES RECEIVED BY OFF-SITE INDIVIDUALS AT NTS SEPTEMBER 15, 1961–SEPTEMBER 4, 1962

Location [a]	Period of time in which exposure occurred [b]	Total exposure	Exposure from fallout
		(*mr*)	(*mr*)
Caliente	1–31–62 to 8–28–62	245	141
Casey Ranch	5–16–62 to 8–8–62	230	188
Do	do	260	218
Do	do	285	243
Diablo	5–15–62 to 8–16–62	265	220
Do	2–7–62 to 8–16–62	330	285
Nyala	5–16–62 to 8–8–62	290	248
Do	do	435	393
Do	6–20–62 to 8–8–62	310	285
Do	5–16–62 to 8–8–62	480	438
Penoyer Ranch	3–5–62 to 8–16–62	260	178
Pine Creek Ranch	5–24–62 to 8–8–62	345	307
Do	do	255	217
Twin Springs	5–15–62 to 8–16–62	290	245
Do	2–13–62 to 8–16–62	265	173
Blue Eagle Ranch	6–12–62 to 9–5–62	205	161
Do	5–9–62 to 9–5–62	200	140
Do	6–11–62 to 8–10–62	255	225
Do	5–16–62 to 9–6–62	285	229
Duckwater	5–19–62 to 9–4–62	215	161
Gardner Ranch	2–14–62 to 9–5–62	395	294
Hiko	2–20–62 to 9–3–62	340	243
Lockes	2–6–62 to 9–4–62	215	110
Manzonie Ranch	2–13–62 to 9–4–62	280	179
Do	do	210	109

[a] Each entry represents a different individual.
[b] These dates vary because not all individuals were residing in the area during the entire testing period.

TABLE II.—LOCATIONS AND NUMBER OF PEOPLE WEARING FILM BADGES THAT RECORDED NO IDENTIFIABLE RADIATION EXPOSURE[a] ABOVE NATURAL BACKGROUND SEPTEMBER 15, 1961–AUGUST 25, 1962

St. George, Utah	15 people
Littlefield, Ariz	2 people
Beatty, Nev	26 people
Furnace Creek, Nev	8 people
Lathrop Wells, Nev	16 people
Pahrump, Nev	10 people
Rhyolite, Nev	2 people
Springdale, Nev	1 person
Tonapah, Nev., Area	32 people

[a] Exposures less than 30 mr cannot be determined accurately from these film badges.

TABLE III.—NUCLEAR EVENTS AT NEVADA TEST SITE SEPTEMBER 15, 1961–DECEMBER 31, 1962

Date	*Type shot*[1]	*Footnotes*
Sept. 15, 1961	Low yield—Underground	2, 3
Sept. 16, 1961	----do	1, 4
Oct. 10, 1961	----do	2, 3
Oct. 29, 1961	----do	2, 4
Dec. 3, 1961	----do	1, 4
Dec. 13, 1961	----do	1, 4
Dec. 17, 1961	----do	1, 4
Dec. 22, 1961	----do	2, 4
Jan. 9, 1962	----do	1, 4
Jan. 18, 1962	----do	2, 4
Jan. 30, 1962	----do	2, 4
Feb. 8, 1962	----do	1, 4
Feb. 9, 1962	----do	2, 4
Feb. 15, 1962	----do	2, 4
Feb. 19, 1962	----do	2, 4
Feb. 19, 1962	----do	2, 4
Feb. 23, 1962	----do	1, 4
Feb. 24, 1962	----do	2, 4
Mar. 1, 1962	Low yield—U.S.—U.K. test of British device	2, 3
Mar. 5, 1962	Shallow depth, Low yield, Underground	5, 3
Mar. 6, 1962	Low yield—Underground	1, 4
Mar. 8, 1962	----do	2, 4
Mar. 15, 1962	----do	1, 4
Mar. 28, 1962	----do	1, 4
Mar. 31, 1962	Low yield—Underground	1, 4
Apr. 5, 1962	----do	1, 4
Apr. 6, 1962	----do	1, 4
Apr. 12, 1962	----do	1, 4
Apr. 14, 1962	----do	5, 3
Apr. 21, 1962	----do	1, 4
Apr. 27, 1962	----do	1, 4
May 7, 1962	----do	1, 4
May 12, 1962	Intermediate yield—Underground	1, 4

See footnotes at end of table.

TABLE III.—NUCLEAR EVENTS AT NEVADA TEST SITE SEPTEMBER 15, 1961–DECEMBER 31, 1962—Continued

Date	*Type shot* [7]	*Footnotes*
May 19, 1962	Low yield—Underground	5, 3
May 25, 1962	----do	1, 4
June 1, 1962	----do	1, 4
June 6, 1962	----do	1, 4
June 13, 1962	----do	5, 3
June 21, 1962	----do	1, 4
June 27, 1962	Intermediate yield—Underground	2, 4
June 28, 1962	Low yield—Underground	2, 3
June 30, 1962	----do	1, 4
July 6, 1962	Plowshare cratering experiment	5, 6, 3
July 7, 1962	Low yield slightly above ground	5, 4
July 11, 1962	Shallow depth low yield	5, 3
July 13, 1962	Low yield—Underground	1, 4
July 14, 1962	Low yield few feet above ground	5, 3
July 17, 1962	Low yield slightly above ground	5, 3
July 23, 1962	Low yield—Underground	2, 4
Aug. 24, 1962	----do	1, 4
Aug. 24, 1962	----do	1, 4
Sept. 14, 1962	----do	1, 4
Sept. 20, 1962	----do	1, 4
Sept. 29, 1962	----do	2, 3
Oct. 5, 1962	Intermediate yield—Underground	1, 4
Oct. 12, 1962	Low yield—Underground	1, 4
Oct. 19, 1962	----do	5, 3
Oct. 27, 1962	----do	1, 4
Nov. 27, 1962	----do	2, 3
Dec. 7, 1962	Low yield—US–UK test of British device	1, 4
Dec. 12, 1962	Low yield—Underground	1, 4
Dec. 12, 1962	----do	1, 4

Footnotes:

1. No release of radioactivity occurred.
2. Release of small quantities of steam and/or a gaseous cloud containing small quantities of radioactivity.
3. Some activity detected off-site.
4. No activity detected off-site.
5. A radioactive cloud produced.
6. 635 feet underground-cratering shot—less than 30 KT fission.
7. Low yield—20 KT or less.
   Intermediate yield—between 20 KT and 1 MT.

TABLE IV.—HIGHEST CONCENTRATIONS OF I–131 IN INDIVIDUAL SAMPLES OF MILK IN NEVADA

September 1, 1961–July 1, 1962

Location	*Date*	*Levels (μμc/l)*
Hiko, Nev	Nov. 2, 1961	720
Elko, Nev	June 21, 1962	610
Robbins Ranch, Nev	June 22, 1962	520
Austin, Nev	June 30, 1962	180
Carlin, Nev	June 22, 1962	160
Eureka, Nev	June 23, 1962	110
Fallini's Ranch, Nev	Nov. 29, 1961	90
Wendover, Nev	June 29, 1962	90
* * * * * * *		

10 other measurements between 10 and 80 μμc/l
26 other measurements less than 10 μμc/l

TABLE V.—HIGHEST CONCENTRATIONS OF I–131 IN INDIVIDUAL SAMPLES OF MILK IN (a) NEVADA AND (b) UTAH—JULY 1962

(a) Nevada (Based on 66 samples from 23 sources)

Location	*Date*	*Levels (μμc/l)*
Caliente, Nev	July 19, 1962	6, 900
Do	July 23, 1962	3, 500
Fallini's Ranch, Nev	-----do------	3, 200
Ely, Nev	July 24, 1962	2, 800
Alamo, Nev	July 17, 1962	2, 300
Ely, Nev	July 26, 1962	2, 000
Caliente, Nev	July 25, 1962	1, 800

(b) Utah (Based on 53 samples from 9 sources)

Snyderville, Utah	July 20, 1962	9, 000
Do	-----do------	5, 400
Do	July 25, 1962	4, 400
Oakley, Utah	----do------	4, 400
Do	----do------	4, 200
Snyderville, Utah	July 27, 1962	3, 000
Kamas, Utah	----do------	2, 600
Oakley, Utah	----do------	2, 600
Do	July 30, 1962	2, 200

TABLE VI.—HIGHEST CONCENTRATIONS OF I–131 IN MILK IN (a) NEVADA AND (b) UTAH AUGUST 1962

(a) Nevada

Location	Date	Levels (μμc/l)
Caliente, Nev	8– 1–62	1, 000
Pioche, Nev	8– 8–62	1, 000
Alamo, Nev	8– 2–62	420
Ely, Nev	8– 2–62	410
Lund, Nev	8–10–62	400
Panaca, Nev	8– 6–62	370
Las Vegas, Nev	8– 1–62	260

(b) Utah

Kamas, Utah	8– 3–62	1, 500
Do	8– 6–62	1, 500
Oakley, Utah	8– 3–62	1, 200
Snyderville, Utah	8– 9–62	880
Do	8– 3–62	740
Vernal, Utah	8–21–62	570
Ogden, Utah	8– 2–62	260
Logan, Utah	8– 1–62	130

TABLE VII.—HIGHEST CONCENTRATIONS OF I–131 IN MILK IN NEVADA AND UTAH SEPTEMBER 1962

Location	Date	Levels (μμc/l)
Blue Eagle Ranch, Nevada	9–12–62	130
Do	9– 6–62	90
Logan, Utah	9– 4–62	70
Do	9– 6–62	60
Caliente, Nevada	9– 6–62	60
White River Valley, Nevada	9– 7–62	60
Do	9–13–62	60

TABLE VIII.—HIGHEST GROSS BETA AIR ACTIVITY FOR OFF-SITE COMMUNITIES IN NEVADA

Location	Time	Date	Concentration (μμc/M³)
1. Diablo	0905–1637	July 6, 1962	13, 000
2. Diablo	1645–2000	do	33, 000
3. Ely	2000–0800	July 6, 1962–July 7, 1962	7, 300
4. Peyonor Ranch	1105–0245	do	8, 800
5. Warm Springs	0600–1545	July 10, 1962–July 11, 1962	7, 800
6. Alamo	1445–1900	July 14, 1962	140, 000
7. Alamo	0630–1100	July 14, 1962–July 15, 1962	24, 000
8. Caliente	1400–1500	do	9, 300
9. Diablo	1000–1600	July 14, 1962	10, 000
10. Lund	1745–1855	do	10, 000

TABLE IX.—HIGHEST ISOTOPIC AIR RESULTS FOR OFF-SITE COMMUNITIES IN NEVADA

Charcoal Cartridges

Location	Collection Period: Time	Collection Period: Date	(μμc/M³) Midcollection or Cloud Peak Time: I-131	I-133	I-135
Diablo	0905–1637	July 6, 1962–July 6, 1962.	267	13, 500	61, 400
Ely	2000–0800	July 6, 1962–July 7, 1962.	72	2, 550	(a)
Penoyer	1105–0245	----do----------	70	3, 950	9, 200
Diablo	1000–1650	Apr. 14, 1962–Apr. 15, 1962.	55. 3	762	2, 800
Lockes	1315–1315	July 6, 1962–July 7, 1962.	49	202	(a)

Prefilters

Diablo	0905–1637	July 6, 1962–July 6, 1962	3, 560	(a)	(a)
Diablo	0840–1925	June 13, 1962–June 13, 1962	190	2, 700	20, 000
Currant	0800–0800	Apr. 14, 1962–Apr. 15, 1962	400	2, 100	(a)
Diablo	1000–1650	Apr. 14, 1962–Apr. 14, 1962	525	2, 700	2, 000
Caliente	1400–1500	July 14, 1962–July 15, 1962	1, 100	(a)	(a)

[a] Not detectable.

TABLE X.—GROSS BETA ACTIVITY IN WATER

Nevada Test Site Area

Location	Date		Levels (μμc/l)
Diablo	February	1962	51
Furnace Creek	August	1962	32
Ash Meadows	July	1962	70
Lathrop Wells	November	1961	68
Tonopah Test Range	May	1962	98

U.S. Public Health Service Data (March 1962) [a]

Coolidge, Kansas	74
Page, Arizona	43
Peoria, Illinois	58
Cape Girardeau, Missouri	45
Kansas City, Kansas	47

[a] These levels represent some of those recorded for March 1962. The data presented indicate activity associated with dissolved solids in raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in treated water, where such water treatment removes substantially all of the suspended matter. The comparison is made, therefore, between the gross beta activity found in subsurface water supplies which generally are untreated and the gross beta activity in surface water supplies associated with dissolved solids which are not removed by water treatment. They should not be interpretated as average values because levels at many other locations were much lower. (For more complete data, see "Radiological Health Data", Vol. III, No. 9, September 1962.)

FALLOUT FROM ATMOSPHERIC NUCLEAR WEAPONS TEST IN PACIFIC AREA OPERATION DOMINIC

During 1962, the United States announced 30 nuclear detonations in the atmosphere above the Pacific Ocean near Christmas Island and Johnston Island and five high altitude detonations near Johnston Island. The yield of these devices ranged from the low kiloton to the megaton range. The height of burst for all these detonations was such that no local radioactive fallout occurred. The devices were delivered to the point of detonation by manned aircraft or surface-to-air missiles.

In addition to the high altitude and atmospheric tests, the United States announced one underwater test, a low yield nuclear device, detonated in the Eastern Pacific Ocean several hundred miles from the closest land area. This underwater test deposited all of the fission product radioactivity in the ocean. The fission products were mixed and diluted by the sea water and their activity was reduced through decay.

The radiological safety program for the test series was a joint effort among the Joint Task Force Eight (JTF–8) personnel, U.S. Public Health Service personnel assigned to JTF–8 for the test, and personnel from the University of Washington, Seattle, Washington, under contract with the U.S. Atomic Energy Commission.

The on-site program consisted primarily of air and background monitoring and personnel and equipment monitoring on Christmas Island and Johnston Island. The off-site program consisted of a series of cruises by the *Charles F. Gilbert* for collecting environmental samples in the Central Pacific area and a network of 19 monitoring stations established on islands within a radius of 2,000 miles of Christmas Island. In the island network, four were primary stations located on populated islands, manned by officers of the U.S. Public Health Service; six were secondary stations located on more distant islands and populated mainly by JTF–8 personnel who operated the monitoring equipment; nine were background stations located on islands at a considerable distance from the test area. The equipment at the background stations consisted primarily of continuous background recording equipment operated by weather groups or scientific personnel already on the island.

Environmental samples were collected routinely by JTF–8 personnel during the period of April 12–August 15, 1962. Scientific personnel aboard the *Charles F. Gilbert* participated in this environmental sampling program on three cruises, April 24–May 12, 1962, June 4–June 25, 1962, and July 23–August 15, 1962. Approximately 8,000 samples were collected, most of which were returned to the University of Washington for complete analysis. Data from these examinations will not be available until after January 1, 1963.

Preliminary data from beta and gamma radiation scanning of the environmental samples were obtained from the laboratory on Christmas Island. The Hawaiian Surveillance Network (a U.S. Public Health Service activity) collected environmental samples on the Hawaiian Islands during the entire period. Analysis of these samples was made at the Public Health Laboratory, Honolulu, Hawaii.

Preoperational Samples

Radioactivity was detected in samples collected during the preoperational period. Representative findings are presented in Table I for water, milk, and food samples.

Operational Samples

Tables II and III summarize findings for gross beta air activity, precipitation, and drinking water obtained from sampling stations on various islands of the area. It can be seen that gross beta activity in air was low during the entire period of the operation. However, samples of precipitation gave relatively high gross beta readings which are reflected in the drinking water samples.

The levels of radioactivity in native foodstuffs during the test operational period were found to be about the same as that in preoperational samples. Samples of grass and scavola were found to contain high levels of fission product activity. The highest level of gross beta activity detected in grass was 135,000 $\mu\mu c/kg$ for a sample obtained on July 11, 1962, at Rarotonga. Since the gross beta activities in both the grass and drinking water samples were the result of fresh fission product fallout, the activities decreased rapidly with time.

Average gamma radiation levels were taken routinely at all JTF–8 radiological safety stations. Normal background for the islands in the Central Pacific is 0.01 to 0.03 milliroentgens per hour (mr/hr). The greatest increases in gamma background were recorded on Fanning Island on May 6, 1962, on Palmyra Island on June 12, 1962, and on Washington Island on July 14, 1962, with all stations showing a rise to 0.04 mr/hr. Tabulated data indicate that there was no significant change in background in the Central Pacific area as a result of Operation Dominic.

The total radiation exposure due to fallout from Operation Dominic, as recorded by film badges was essentially zero on Christmas Island. The maximum infinity dose on both Penrhyn Island and Washington Island, as calculated by external gamma radiation measurements, was less than 10 mrem. This is below the level of detection on film badges.

Summary of Results During Test Operations

Fanning Island

No significant fallout occurred. An increase in air concentration to 20 $\mu\mu c/M^3$ occurred on May 24, 1962. Fission product activity was detected also in scavola and grass samples. The highest precipitation deposition occurred during the period of June 26–July 8, 1962. However, levels of radioactivity detected in drinking water and food samples collected during and after this period were not significantly different from the levels detected in preoperational samples.

Washington Island

On May 7 and 21, 1962, fission products were detected in precipitation samples. The presence of this radioactivity was reflected also in scavola and grass samples. Levels of fission products in precipitation samples indicated an increase to about 8,700 $\mu\mu c/l$ gross beta on May 14, 1962. However, on the 15th, this activity was decreasing rapidly. Drinking water collected at this time showed 650 $\mu\mu c/l$ gross beta activity, of which 25 $\mu\mu c/l$ was I–131. These levels are too low to constitute a significant health hazard.

Palmyra Island

The highest air concentration was 58 $\mu\mu c/M^3$, observed on June 25, 1962. Other peaks of air activity were 43 $\mu\mu c/M^3$ on May 17, 1962, and 39 $\mu\mu c/M^3$ on June 21, 1962.

Penrhyn Island

On May 13, 1962, the level of I–131 detected in precipitation was 3,600 $\mu\mu c/l$. This was attributed to rain-out involving fresh fission products. If an adult had drunk one liter of this water per day until all of the I–131 activity had decayed away, the total dose to his thyroid would have been less than one rad. However, heavy rains continued in the area for four more days with the precipitation after the first day containing essentially no additional I–131. This, of course, diluted the iodine activity found on May 13, to the point where the integrated dose to the adult's thyroid would have been less than 50 mrads. Similar calculations of dose to a child's thyroid would have resulted in higher values than for adults, but children on Penrhyn drink more coconut milk than water in their normal diet.

Samoa Island

Except for the possibility of some fresh fission debris in grass, no fission products identifiable as resulting from Operation Dominic were detected.

Rarotonga Island

Except for the possibility of some fresh fission debris in grass and precipitation, no fission products identifiable as resulting from Operation Dominic were detected.

Nuka Hiva

On July 14, 1962, air concentration increased to 26 $\mu\mu c/M^3$ gross beta activity. No other identifiable fission products were detected during the testing period.

Johnston Island

Postoperational monitoring is in process at the time of writing this report. No fission products were identifiable as resulting from the Christmas Island portion of Operation Dominic. It is not expected that there will be more fission products at Johnston Island than at Christmas Island.[1]

Other Islands

Traces of radioactivity were detected in air samples and in precipitation in Hawaii, on Christmas Island and Malden Island. No radioactive fallout, identifiable from Operation Dominic events, was detected on Canton Island, Tongatapu Island, Tahiti, Wake Island, Midway Island, French Frigate Shoals, and Kwajalein Island.

Postoperational Samples

Data on the levels of radioactivity found in selected samples collected during the postoperational period are presented in Tables IV and V. The gross beta activity level in food is relatively unchanged from the level in the preoperational

[1] The launching pad on Johnston Island (approximately 1,000 foot radius) was contaminated by scattered fissionable material, following the destruction of a device after a missile malfunction on July 25, 1962. The levels of alpha contamination in this area exceeded the permissible limits; thus, cleanup of the area was required. Cleanup consisted of decontaminating equipment, scrapping the top layer of soil of the areas which were highly contaminated and sealing the contamination on buildings with layers of concrete or paint. The decontamination was completed by mid-August.

samples. Levels of activity in samples of well water in the postoperational period were relatively unchanged from the preoperational samples. The gross beta levels of activity of grass samples in Table IV are lower than those found during the operational phase, as will be noted on the sample from Rarotonga. During the test period, the activity level found was 135,000 $\mu\mu$c/kg; whereas, the level in the postoperational period was reduced to 15,000 $\mu\mu$c/kg.

TABLE I.—JTF–8 OFF-SITE SURVEILLANCE NETWORK, PREOPERATION SAMPLES CHRISTMAS ISLAND—WATER SAMPLES

Type	*Date*	*Location*	*Gross Beta ($\mu\mu$c/l)*	*I–131 ($\mu\mu$c/l)*	*Sr–90 ($\mu\mu$c/l)*
Well water	Apr. 24, 1962	Bamboo Waterhole	4	(*)	0.7
Do	Apr. 20, 1962	London	9	(*)	----------
Do	----do----	----do----	22	(*)	0.3
Do	----do----	----do----	17	(*)	0.5

Christmas Island—Environmental and Food Samples

Type	*Date*	*Location*	*Gross Beta ($\mu\mu$c/kg) wet weight*	*Other Specific Isotopes; e.g., Ce–141, Ce–144, I–131, Ba–140, Cs–137, Zr–Nb–95, Zn–65, Ru–103–106*
Bonefish liver	Apr. 20, 1962	London Reef	----------	(*)
Hermit crab	----do----	London	2,800	(*)
Coconut milk	----do----	JOC	900	Only trace of Cs–137.
Bonefish muscle	----do----	London Reef	3,000	Do.
Langusta muscle	----do----	----do----	1,500	Do.
Langusta shell	----do----	----do----	----------	(*)
Coconut (green)	----do----	London	----------	(*)
Soil	----do----	----do----	----------	(*)
Bonefish muscle	----do----	Y-Site	----------	(*)
Jackfish liver	----do----	----do----	----------	(*)
Jackfish muscle	----do----	----do----	----------	(*)

*Not detectable.

Oahu, Hawaiian Islands—Water, Milk, and Food Samples

Type	Date	Location	Sr–89 (μμc/l)	I–131 (μμc/l)	Ba–140 (μμc/l)	Cs–137 (μμc/l)	Zr–95 (μμc/l)	Ru–103–106 (μμc/l)
Well water	Apr. 10, 1962	Wahiawa	-------	(*)	30	(*)	45	---------
Do	----do------	Kaneohe	--------	25	(*)	(*)	10	---------
Milk	Apr. 5, 1962	Oahu	--------	(*)	(*)	10	--------	---------
Do	Apr. 24, 1962	----do------	40	(*)	(*)	25	--------	---------
					μμc/kg—wet weight			
String beans	Apr. 11, 1962	Oahu	--------	(*)	(*)	15	90	465
Do	----do------	----do------	--------	(*)	(*)	15	20	115
Pineapple	----do------	----do------	4	(*)	(*)	(*)	140	255
Green onion	----do------	----do------	--------	140	(*)	(*)	270	240
Do	----do------	----do------	--------	(*)	(*)	(*)	85	165
Sweet potato	----do------	----do------	8	(*)	(*)	15	10	115
Do	----do------	----do------	--------	(*)	(*)	15	(*)	(*)
Papaya	----do------	----do------	--------	(*)	(*)	25	60	140
Do	----do------	----do------	--------	(*)	(*)	35	50	115
Banana	----do------	----do------	--------	(*)	(*)	(*)	(*)	(*)
Water cress	----do------	----do------	--------	15	(*)	65	135	290
Do	----do------	----do------	3	(*)	(*)	(*)	285	285

*Not detectable.

Fanning Island—Water and Food Samples

		Gross Beta (μμc/l)	Gross Beta (μμc/kg) Wet Weight	Concentrations μμc/kg wet wt. Other Isotopes
Well water	Apr. 21, 1962	85	----------	(*)
Coconut	Apr. 23, 1962	----------	3000	(*)
Papaya	Apr. 22, 1962	----------	2300	100—Zr–95.
Pandanas	----do------	----------	1200	450—Cs–137.
Hermit Crab	Apr. 21, 1962	----------	----------	Trace of Cs–137 and Zn–65.
Lobster Tail	Apr. 22, 1962	----------	6100	(*)
Bonefish	----do------	----------	----------	(*)

Washington Island—Water and Food Samples

Roof water	Apr. 23, 1962	32	----------	Not measured.
Well water	----do------	6	----------	Not measured.
Breadfruit	Apr. 22, 1962	----------	1590	430—Cs–137.
Papaya	----do------	----------	1580	150—Cs–137.
Pandanas	----do------	----------	3200	220—Cs–137.
Coconut (ripe)	----do------	----------	2710	410—Cs–137.
Coconut (grn)	----do------	----------	180	59—Cs–137. 67—Zr–95.
Lobster	Apr. 24, 1962	----------	2300	190—Zr–95. 320—Zn–65.
Octopus	Apr. 28, 1962	----------	2900	250—Zr–95.

American Samoa—Food Samples

Tuna muscle	Apr. 24, 1962	----------	2900	(*).
Do	----do------	----------	3000	(*).
Do	----do------	----------	2800	(*).

*Not detectable.

TABLE II.—JTF–8 OFF-SITE SURVEILLANCE NETWORK GROSS BETA AIR ACTIVITY ($\mu\mu c/M^3$) IN SAMPLES COLLECTED DURING OPERATION DOMINIC

Location	*May 1–30, 1962*	*June 1–30, 1962*	*July 1–15, 1962*
Christmas Island (JOC)	Avg.—3.7	Avg.—4	Avg.—2.1
	Max.—11 (5–20)	Max.—12 (6–9)	Max.—12.5 (7–13)
Christmas Island (London)	Avg.—5.3	Avg.—3.5	Avg.—0.9
	Max.—17 (5–19)	Max.—12.5 (6–9)	Max.—1.4 (7–3)
Christmas Island (A-Site)	Avg.—4	Avg.—3.5	Avg.—0.5
	Max.—15 (5–18)	Max.—12 (6–9)	Max.—1.0 (7–3)
Fanning Island	Avg.—5.4	Avg.—4.4	Avg.—1.0
	Max.—20.5 (5–24)	Max.—14.5 (6–3)	Max.—2.7 (7–11)
Washington Island	Avg.—3.5	Avg.—2.7	Avg.—1.1
	Max.—13.5 (5–18)	Max.—13 (6–10)	Max.—4.5 (7–15)
Honolulu, Hawaii	Avg.—2	Avg.—1.9	Avg.—1.6
	Max.—4.4 (5–17)	Max.—3.5 (6–2)	Max.—3.5 (7–26)
Palmyra Island	Avg.—4.7	Avg.—8	Avg.—2
	Max.—43 (5–17)	Max.—39 (6–21)	Max.—7 (7–14)
		Max.—57.7 (6–25)	
Malden Island	Avg.—5.4	Avg.—3.9	Avg.—1
	Max.—19 (5–15)	Max.—11.2 (6–10)	Max.—2 (7–11)
Penrhyn	No Data	Avg.—2.4	Avg.—3.4
		Max.—7 (6–28)	Max.—13.5 (7–10)
Canton Island	Avg.—5.5	Avg.—5.5	Avg.—3.3
	Max.—19 (5–17)	Max.—24.5 (6–2)	Max.—6.8 (7–1)
Johnston Island	No Data	Avg.—1.4	Avg.—3
		Max.—2.5 (6–11)	Max.—10.5 (7–19)
Wake Island	No Data	Avg.—1.5	Avg.—1.1
		Max.—3 (6–14)	Max.—3.4 (7–3)
Midway Island	No Data	Avg.—1.5	Avg.—1
		Max.—3.7 (6–13)	Max.—2.3 (7–19)
French Frigate Shoals	No Data	Avg.—2	Avg.—2.1
		Max.—4.6 (6–22)	Max.—4.8 (7–22)
Kwajelin Island	No Data	Avg.—1.9	Avg.—0.9
		Max.—4 (6–27)	Max.—3.2 (7–7)
Tahiti	No Data	Avg.—0.65	Avg.—0.9
			Max.—4.5 (7–12)
Nuku Hiva	No Data	Avg.—1	Avg.—2
		Max.—3 (6–13)	Max.—26 (7–14)

TABLE III.—JFT–8 OFF–SITE SURVEILLANCE NETWORK PRECIPITATION SAMPLES COLLECTED DURING OPERATION DOMINIC

Location	Date	Gross Beta (μμc/l)	Iodine-131 (μμc/l)
Honolulu, Hawaii	4-26-62	410	----------
Do	5-21-62	1,400	----------
Kaneohe, Hawaii	7- 5-62	700	----------
Christmas Island	5- 9-62	5,100	----------
Do	6- 1-62	670	(a)
Christmas Island (JOC)	7-19-62	800	40
Christmas Island (London)	6-11-62	920	25
Christmas Island (A-Site)	6- 1-62	580	(a)
Fanning Island	5- 7-62	1,200	----------
Do	5-21-62	2,000	19
Do	7- 8-62	14,000	(a)
Washington Island	5- 7-62	3,700	(a)
Do	5-21-62	1,200	90
Do	7-14-62	8,700	37
Do	7-15-62	4,900	113
Malden Island	6- 9-62	550	51
Penrhyn Island	5-13-62	257,000	3,600
Canton Island	5-31-62	310	(a)
Nuka Hiva	6-16-62	25	(a)
Tahiti	6-30-62	69	31
Viti Levu	7-20-62	420	(a)
Samoa	6-30-62	2,900	(a)
Tongatapu	7-13-62	103	(a)
Roratonga	6-30-62	6,700	(a)

DRINKING WATER SAMPLES

Location	Type	Date	Gross Beta (μμc/l)	I-131 (μμc/l)	Sr-90 (μμc/l)
Christmas Island	well	4-28-62	150	----------	----------
Do	----do	6-24-62	16	23	----------
Penrhyn Island	cistern	6- 8-62	330	18	----------
Do	----do	6- 9-62	470	20	0.4
Tongatapu Island	----do	7-13-62	103	(a)	----------
Rarotonga	----do	7-11-62	128	(a)	----------

[a] Not detectable.

TABLE IV.—JTF-8 OFF-SITE SURVEILLANCE NETWORK POSTOPERATION ENVIRONMENTAL AND FOOD SAMPLES BY ISLAND

Location	Type	Date	Radionuclide Concentration uuc/kg of wet weight						
			Gross Beta	Ce^{-141}, ^{144} a	I^{-131}	Ba^{-140}	Cs^{-137}	$ZrNb^{-95}$	Ru^{-103}, ^{106} a
Christmas Island	Scavola	July 16, 1962	4,300	3,600	nd	5,200	nd	----------	----------
Do	Ripe Coconut	do	4,300	nd	nd	nd	nd	nd	nd
Do	Green Coconut	do	1,800	nd	nd	nd	nd	nd	nd
Do	Soil	do	nd	2,100	nd	nd	nd	2,600	400
Hawaii (Oahu)	Pineapple	July 31, 1962	nd	----------	nd	nd	110	30	nd
Hawaii (Kauai)	Lettuce	do	820	----------	nd	nd	nd	Trace	nd
Hawaii (Oahu)	do	do	Incomp	----------	----------	----------	----------	----------	----------
Do	Milk	do	----------	----------	nd	nd	35	----------	----------
Fanning Island	Scavola	July 13, 1962	27,800	8,600	500	3,400	nd	8,000	[a] 1,100
Do	Coconut	do	1,800	nd	nd	nd	230	nd	nd
Do	Coconut Milk	do	789	nd	nd	nd	nd	nd	nd
Do	Soil	do	----------	1,400	nd	nd	nd	2,250	2,500
Washington Island	Ripe Coconut	do	1,800	Trace	nd	nd	280	nd	nd
Do	Green Coconut	do	1,100	Trace	nd	nd	110	nd	nd
Do	Scavola	July 15, 1962	11,000	[a] 8,500	900	4,000	nd	6,000	[a] 1,200
Do	Soil	do	6,500	1,400	nd	870	nd	1,350	580
Do	Eggs	do	980	nd	nd	nd	nd	nd	nd
Penrhyn Island	Soil	July 19, 1962	1,800	11,850	nd	nd	nd	3,810	480
Viti Levu, Fiji	do	July 25, 1962	nd	nd	nd	nd	Trace	340	nd
Do	Grass	do	30,000	[a] 6,300	nd	2,400	nd	16,000	4,900
Tutuila, Samoa	Soil	July 21, 1962	nd	nd	nd	nd	nd	650	2,100
Do	Grass	July 31, 1962	35,000	[a] 19,000	nd	9,000	nd	47,000	[a] 7,500
Tongatapu	Soil	July 24, 1962	nd	nd	nd	nd	Trace	Trace	nd
Do	Grass	do	7,500	2,600	nd	1,000	nd	24,000	[a] 1,000
Do	Milk	do	----------	nd	10	42	20	190	nd
Rarotonga	Soil	July 21, 1962	nd	55	nd	nd	nd	72	23
Do	Grass	do	15,000	nd	nd	Trace	nd	25,000	2,000
Canton Island	Soil	July 20, 1962	----------	600	nd	nd	nd	1,100	580

[a] If Ru and Ce activities are marked with an [a], the activity reported is assumed to be from the shorter lived isotopes Ru^{-103} and Ce^{-141}. Otherwise the activity is assumed to be due to the longer lived isotopes Ru^{-106} and Ce^{-144}.

TABLE V.—JTF-8 OFF-SITE SURVEILLANCE NETWORK POSTOPERATION WATER SAMPLES BY ISLAND

Location	*Type*	*Date*	*Gross Bata (μμc/l)*
Christmas (Bamboo)	Well	July 15, 1962	10
Christmas (Decca)	----do	----do	10
Christmas (Banana)	----do	----do	20
Oahu (Wahiawa)	City	July 31, 1962	13
Oahu (Kaimuki)	----do	----do	10
Oahu (Honolulu West)	----do	----do	10
Oahu (Kaneohe)	----do	----do	10
Fanning Island	Well	July 11, 1962	10
Washington Island	----do	July 13, 1962	35
Do	Cistern	July 15, 1962	650
Penrhyn Island	----do	July 19, 1962	320
Canton Island	----do	July 20, 1962	23
Tutuila Samoa	City	July 21, 1962	10
Tongatapu	Cistern	July 24, 1962	20
Rarotonga	City	July 22, 1962	10

RADIOACTIVITY RELEASED BY UNDERGROUND EXPERIMENT NEAR CARLSBAD, NEW MEXICO

The first nuclear detonation in the Commission's Plowshare program to develop peaceful uses for nuclear explosives was Project Gnome, a multipurpose experiment in a salt bed 25 miles southeast of Carlsbad, New Mexico. The nuclear device, with a yield of about three kilotons, was detonated at noon, MST, on December 10, 1961; 1,200 feet underground.

The detonation raised a small cloud of dust from the surface. Shortly, thereafter a white vapor was seen issuing from the mouth of the 1,200 foot vertical shaft. This vapor, holding close to the ground, was blown north-northwest, to the east of the city of Carlsbad. There was no evidence of venting in the vicinity of surface ground zero.

Monitoring results demonstrated that the cloud was largely gaseous in nature. Although every effort had been made to minimize the deposition of radioactivity in any inhabited off-site area, small amounts of short-lived radioactivity were deposited in the path of the cloud for the first ten miles or so.

The following is a summary of the data obtained by the U.S. Public Health Service Off-Site Radiological Safety Organization in the vicinity of the test site.

External Gamma Exposure

Monitors conducted a film badge program to give an account of accumulated radiation doses off-site. Three hundred and thirty film badges were placed on individuals and structures within a one hundred mile radius of the test site. These badges were left out for about 30 days. Six badges recorded radiation exposure. The highest film badge exposures were from Hudson Farm, 18 miles north, northwest of the test site. A badge located outside recorded 165 mr, while a badge worn by a person at the farm recorded 140 mr. Film badges placed on two houses on the east and north sides of Illinois Camp (27 miles north, northwest from the test site) recorded 80 mr and 50 mr respectively. The occupant of the second house wore a film badge that recorded 40 mr. These doses measured by film badges have *not* been corrected for natural background radiation exposure, which is approximately 0.5 mr/day.

Milk

Milk samples were collected from eight producer dairies in the vicinity of the Gnome site. Results indicate that no increase of radioactivity was detected in the milk supplies from the Gnome event.

Mine Surveys

Eight mines located within a 30 mile radius from the Gnome site were monitored for external beta-gamma levels before and after the shot event. The two sets of readings remained the same within the tolerance of the instruments used.

Air Sampling

Of the 20 air samplers in operation, only a few filters showed any appreciable increase of gross beta activity, with the highest reading 160 $\mu\mu c/M^3$ for a 16¾ hour sampling period. The highest iodine concentrations found in air were 1.7 $\mu\mu c/M^3$ of I–131 and 18 $\mu\mu c/M^3$ of I–133 on December 11, 1961, and 3.5 $\mu\mu c/M^3$ of I–135 on December 10. 1961. All of the above were well below permissible levels for the general population.

Water Sampling

Fourteen water sampling points were selected in the vicinity of the Gnome event. No significant difference was found between the post-test and the pre-test water samples collected and analyzed for radioactive content.

Animal Sampling

Five cattle were slaughtered prior to the Gnome event and five more about a month after the detonation, for radiochemical analysis of their body tissues and organs. The radioactive concentrations from the pre- and post-shot samples were found to be comparable.

Surface Contamination

Although the radioactivity released following this experiment was largely gaseous in form, there was some particulate fallout in the local area. Some vehicles passing along Highways 31 and 128 (about nine miles from ground zero) were contaminated; the highest readings being about 200 mr/hr around the radiator and 150 mr/hr around the tires at about one hour after shot time. The highest reading inside the cars was 15 mr/hr. Seven cars were washed with the results that the highest reading was 15 mr/hr around the radiator and eventually background inside the car. Two individuals were found to have slight amounts of contamination (one on the hand and one in the hair), *i.e.*, less than 1 mr/hr (beta plus gamma). This contamination was removed by washing.

APPENDIX 16

COMMISSION'S FINANCIAL REPORT FOR FISCAL YEAR 1962

INTRODUCTION

The Atomic Energy Commission is an independent agency, responsible to the President and Congress, created in fiscal year 1947 to perform the atomic energy functions previously assigned to the Army and further to encourage the peaceful uses of atomic energy. To do this, the AEC is responsible for activities involving manufacturing, basic and applied research, and regulating the peaceful uses of atomic energy.

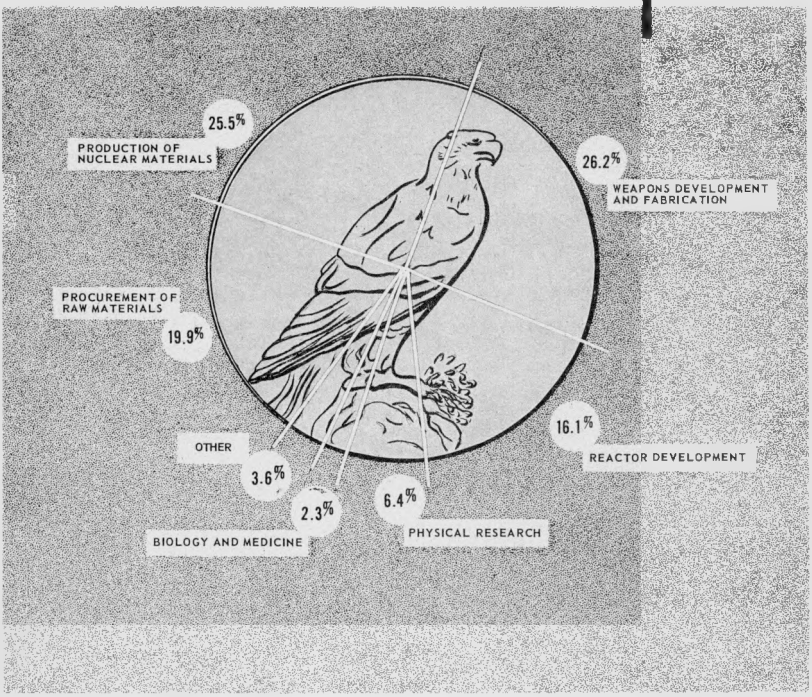
Funds are provided to AEC in two congressional appropriations—one for construction and one for operations. The AEC accounting system therefore must comply with the requirements of Federal Government accounting. However, since AEC is engaged in large industrial and research activities, its management requires knowledge of the cost of each step in its operations. The AEC accounting system provides this through the application of commercial accrual and cost accounting principles. For AEC, both governmental and commercial accounting have been combined into a single system. The principles of both, therefore, underlie the preparation of this report.

Most of the work involved in actually achieving the AEC goals is performed by commercial firms, or educational or other non-profit organizations under contract to the AEC. Government-owned facilities are operated by contractors who maintain complete accounting records on those activities. The report contained in the following pages is a consolidation of unclassified information obtained from financial reports submitted to AEC by the contractors as well as information obtained from the AEC records. Except for the exclusion of information relating to weapons and production inventories for security reasons, the report shows the AEC assets, liabilities and equity, and the costs incurred by the AEC in carrying out its responsibilities.

Costs shown in this report include depreciation unless specifically noted to the contrary.

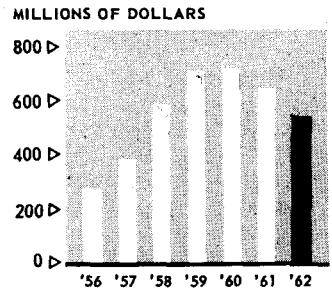
1962 OPERATING COSTS

	millions	
TOTAL	$2,695.9	100%
PROCUREMENT OF RAW MATERIALS	537.4	19.9
PRODUCTION OF NUCLEAR MATERIALS	688.5	25.5
WEAPONS DEVELOPMENT AND FABRICATION	705.9	26.2
REACTOR DEVELOPMENT	433.2	16.1
PHYSICAL RESEARCH	171.8	6.4
BIOLOGY AND MEDICINE	62.8	2.3
OTHER	96.3	3.6



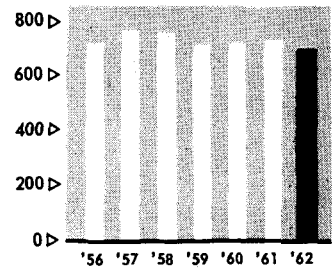
PRODUCTION HIGHLIGHTS

The cost of procurement of raw materials in fiscal year 1962 continued to decline from the high point reached in 1960 because of continued reductions in both quantities purchased and the average cost per pound of U_3O_8 (see the opposite page).



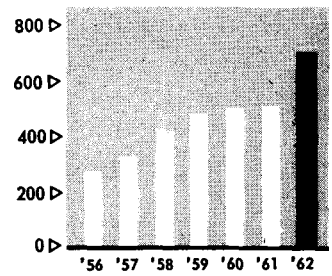
PROCUREMENT OF RAW MATERIALS

The cost of production of nuclear materials reached a seven year low of $689 million in fiscal year 1962. This is due principally to improvements in production methods.



PRODUCTION OF NUCLEAR MATERIALS

Compared with fiscal year 1961 the cost of weapons development and fabrication increased approximately $194 million. This is due in large part to the resumption of full scale weapons tests.



WEAPONS DEVELOPMENT & FABRICATION

PROCUREMENT OF RAW MATERIALS

Procurement of raw materials in fiscal year 1962 amounted to $537 million and involved almost exclusively uranium concentrates (U_3O_8), whereas the procurement of raw materials in fiscal year 1961 amounted to $637 million and involved $627 million for uranium concentrates and $10 million for other raw materials.

The reduction of $90 million in U_3O_8 purchases was due principally to a continuation of arrangements to defer deliveries of uranium concentrates from Canada and reductions of average unit costs.

The table below shows the origin of AEC's procurement in millions of dollars and tons of U_3O_8 for fiscal years 1962 and 1961.

	Total Cost		Quantity		Average Cost	
	1962	1961	1962	1961	1962	1961
	(in millions)		*(tons U_3O_8)*		*(dollars per lb)*	
U_3O_8 Purchases						
Domestic	$283	$303	17,255	17,758	$ 8.20	$ 8.54
Canadian	154	224	7,728	10,251	9.95	10.91
Overseas	100	100	4,379	4,251	11.48	11.78
Total	$537	$627	29,362	32,260	$ 9.15	$ 9.72

At the end of fiscal year 1962 AEC had commitments for the procurement of 97,000 tons of U_3O_8 amounting to $1.6 billion as shown below.

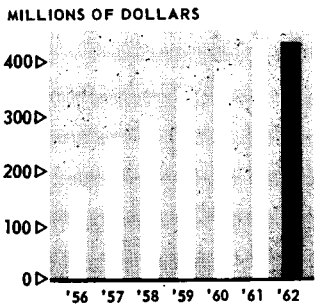
U_3O_8 PROCUREMENT COMMITMENTS

(in millions)

Domestic	$1,159
Canadian	174
Overseas	293
	$1,626

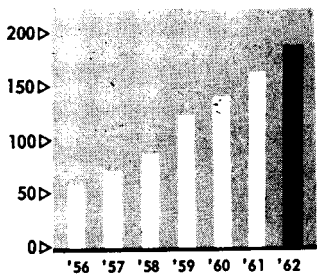
RESEARCH AND DEVELOPMENT HIGHLIGHTS

The cost of research and development on nuclear reactors decreased $4 million in fiscal year 1962. This is due principally to cost reductions from discontinuing the aircraft propulsion research offset in part by increased effort on space propulsion and auxiliary power sources.



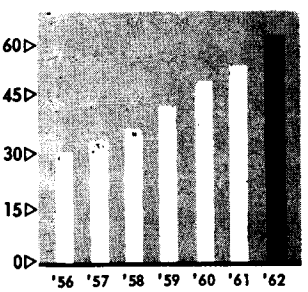
REACTOR DEVELOPMENT

The cost of physical research increased $18 million in fiscal year 1962. This increase is accounted for principally by increased research on high energy physics, chemical properties and reactions, and metallurgy and materials.



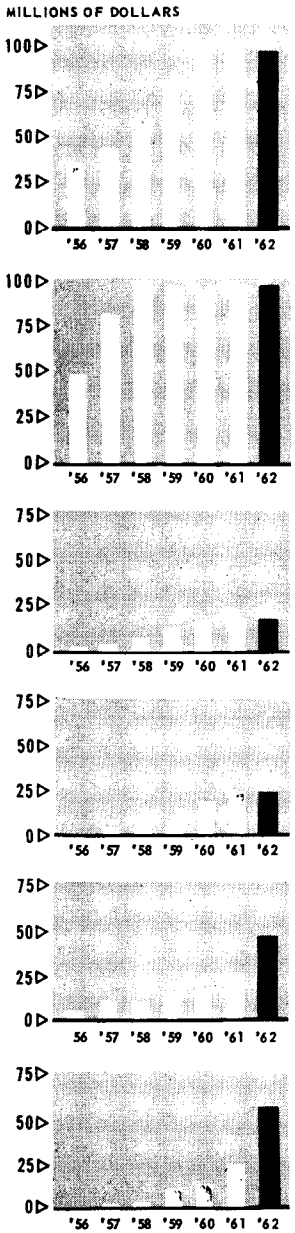
PHYSICAL RESEARCH

The cost of biomedical research increased $9 million in fiscal year 1962. This was mostly due to increased efforts in somatic effects of radiation and environmental radiation studies.



BIOLOGY AND MEDICINE

REACTOR DEVELOPMENT Cost Trends



CIVILIAN NUCLEAR POWER REACTORS

The cost of developing civilian nuclear power declined in fiscal year 1962 to $94.3 million largely because of completion of pre-construction research and development assistance to Philadelphia Electric Company and discontinuing the East Central and Florida West Coast nuclear power reactor.

NAVY REACTORS

The cost of work on naval propulsion reactors has remained relatively stable since fiscal year 1958.

ARMY REACTORS

The reduction in the cost of work on army power reactors in fiscal year 1962 was due principally to deferral of work on compact reactors.

MISSILE PROPULSION REACTORS

The cost of developing missile propulsion reactors remained at approximately the same level as in fiscal year 1961.

SPACE PROPULSION REACTORS

Increasing emphasis on development of space propulsion reactors is indicated by the cost trend. Fiscal year 1962 costs of $42.5 were nearly 1.7 times the 1961 costs and more than 10 times the 1956 costs.

AUXILIARY POWER SOURCES

The cost trend of auxiliary power sources has increased substantially from less than $.5 million in fiscal year 1956 to $53.6 million in 1962.

REACTOR DEVELOPMENT

Cost Summary

	Research and Development Costs*		
	Cumulative Through June 30, 1962	Fiscal Year 1962	Fiscal Year 1961
		(in millions)	
CIVILIAN NUCLEAR POWER REACTORS†			
Pressurized light water	$ 177.4	$ 26.2	$ 26.2
Boiling light water	61.8	10.1	11.9
Heavy water	37.7	10.0	9.3
Organic moderated	42.3	10.2	8.2
Gas cooled	66.2	12.5	21.4
Sodium cooled	156.9	23.6	22.2
Other studies and development	9.1	1.7	3.1
Total	551.4	94.3	102.3
MILITARY REACTORS			
Naval propulsion	745.7	95.4	93.5
Army power	58.2	12.8	13.5
Missile propulsion	79.4	21.5	23.1
Aircraft propulsion‡	472.4		71.1
Total	1,355.7	129.7	201.2
SPACE PROPULSION	116.7	42.5	25.1
OTHER			
Merchant ship reactors	22.8	9.0	5.4
Auxiliary power sources	99.4	53.6	21.3
General	750.8	104.1	82.0
Total	873.0	166.7	108.7
TOTAL REACTOR DEVELOPMENT COSTS	$2,896.8	$433.2	$437.3

*Does not include funding by other Federal agencies.

†Does not include costs of private organizations participating in the power demonstration reactor program.

‡Discontinued in 1961.

Cooperative Power Reactor Projects

In its Power Demonstration Reactor Program, the Atomic Energy Commission cooperates with other organizations—both private and public—in nuclear power plant demonstration projects.

The table below and on the next two pages shows AEC and private industry participation in cooperative projects for the development and construction of nuclear power plants.

	Date of Criticality and Plant Capacity ekw (net)	Cumulative June 30, 1962		Total Estimated	
		AEC Assistance	Participant's Costs*	AEC Assistance	Participant's Costs*
		(in millions)			
Yankee Atomic Electric Co. Rowe, Mass.	Commenced Operations				
Research and development	July 1961	$ 5.0	$ .2	$ 5.0	$ .2
Plant, equipment and land	141,000 ekw		39.2		39.2
Waiver of use charges		1.8		3.7	
Fuel fabrication			1.7		1.7
Total		6.8	41.1	8.7	41.1
Power Reactor Development Co., Lagoona Beach, Michigan	January 1963 60,900 ekw				
Research and development		2.9	22.9	3.6	25.8
Plant, equipment and land			60.4		65.1
Waiver of use charges		2.7		3.7	
Fuel fabrication			3.8		4.0
Total		5.6	87.1	7.3	94.9
Rural Cooperative Power Association, Elk River, Minnesota	November 1962 22,000 ekw				
Plant, equipment and land		9.2	1.6	10.8	1.6
Fuel fabrication		.5		.9	
Total		9.7	1.6	11.7	1.6
City of Piqua Piqua, Ohio	October 1962 11,400 ekw				
Research and development		3.5		3.5	
Plant, equipment and land		8.0	3.9	8.9	3.9
Fuel fabrication		1.0		1.6	
Total		12.5	3.9	14.0	3.9
Consumers Public Power District, Hallam, Neb.	September 1962 76,000 ekw				
Research and development		15.6		16.4	
Plant, equipment and land		29.4	18.8	31.1	20.6
Fuel fabrication		2.6		4.1	
Total		47.6	18.8	51.6	20.6

	Date of Criticality and Plant Capacity ekw (net)	Cumulative June 30, 1962		Total Estimated	
		AEC Assistance	Participant's Costs*	AEC Assistance	Participant's Costs*
		(in millions)			
Northern States Power Co. Sioux Falls, S. D.	September 1962 62,000 ekw				
Research and development		$ 6.9	$ .3	$ 8.5	$ .3
Plant, equipment and land			21.7		22.6
Waiver of use charges		.5		1.8	
Fuel fabrication			.8		3.5
Total		7.4	22.8	10.3	26.4
Carolinas-Virginia Nuclear Power Assoc., Inc. Parr, South Carolina	December 1962 17,000 ekw				
Research and development		8.6	1.6	12.3	2.3
Plant, equipment and land			15.5		20.8
Waiver of use charges		.1		1.2	
Fuel fabrication			1.0		1.3
Total		8.7	18.1	13.5	24.4
Consumers Power Co. of Michigan Big Rock Point, Mich.	September 1962 47,808 ekw				
Research and development		2.3	.2	4.6	.3
Plant, equipment and land			24.4		27.4
Waiver of use charges		.1		1.7	
Fuel fabrication			.4		1.2
Total		2.4	25.0	6.3	28.9
Philadelphia Electric Co. York County, Pa.	September 1964 40,015 ekw				
Research and development		12.5	6.4	14.5	6.9
Plant, equipment and land			8.6		29.1
Waiver of use charges		.2		2.5	
Fuel fabrication					1.0
Total		12.7	15.0	17.0	37.0
Puerto Rico Water Resources Authority, Punta Higuera, Puerto Rico	August 1963 16,300 ekw				
Research and development		1.6	.2	2.0	.2
Plant, equipment and land		6.5	3.8	10.2	4.6
Fuel fabrication		.7		3.9	
Total		8.8	4.0	16.1	4.8

	Date of Criticality and Plant Capacity ekw (net)	Cumulative June 30, 1962		Total Estimated	
		AEC Assistance	Participant's Costs*	AEC Assistance	Participant's Costs*
		(in millions)			
Dairyland Power Cooperative Genoa, Wisconsin	October 1965 50,000 ekw				
Plant, equipment and land		$	$	$ 11.7	$ 7.8
Fuel fabrication				2.4	
Total				14.1	7.8
Summary	544,423 ekw				
Research and development		58.9	31.8	70.4	36.0
Plant, equipment and land		53.1	197.9	72.7	242.7
Waiver of use charges		5.4		14.6	
Fuel fabrication		4.8	7.7	12.9	12.7
Total		$122.2	$237.4	$170.6	$291.4

*As reported by participant.

Space Propulsion

The cost of research and development on reactors designed for propulsion of vehicles in the probe of space increased to $42 million in fiscal year 1962 from $25 million in 1961, an increase of $17 million or 68 percent.

The following table shows the 1962 cost of research on space propulsion. A comparable breakdown for 1961 costs is not available.

	Fiscal Year 1962
	(in thousands)
Kiwi (non-flyable experimental reactors)	$22,926
Nerva (nuclear engine for rocket vehicle application)	7,642
Advanced technology	3,396
Nuclear rocket development station operations	8,491
Total	$42,455

Auxiliary Power Sources

The cost of research and development on reliable, lightweight sources of auxiliary power for use in space vehicles and other specialized applications amounted to $54 million in fiscal year 1962 compared with $21 million in 1961, an increase of $33 million or 151 percent.

The following table shows the cost comparison of the types of Auxiliary Power for 1962 and 1961.

	Fiscal Year	
	1962	1961
	(in thousands)	
Radioisotope power systems	$ 4,268	$ 2,919
Reactor space power systems	31,500	14,323
Advanced space power systems (including Snap 50)	17,804	4,074
Total	$53,572	$21,316

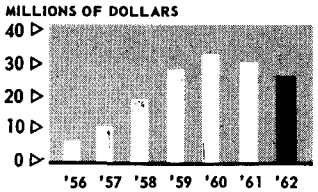
N. S. *Savannah*

The first nuclear-powered merchant ship, N. S. *Savannah*, began its demonstration operations on August 22, 1962. The *Savannah* was developed as a joint AEC-Maritime Administration project directed toward the development of competitive nuclear merchant ships and as a demonstration of the peaceful uses of atomic energy. Total cost to construct the ship and the nuclear power plant was $47.5 million. AEC's share of these costs was $28.8 million, including the initial fuel assembly. In addition, AEC has incurred costs of $22.4 million for research, development, training the crew to operate the reactor and to conduct the sea trials, and $1.7 million for fabrication of a replacement fuel assembly.

The *Savannah* is powered by an especially designed pressurized water nuclear reactor. It is 595½ feet long, displaces 24,416 short tons with a cargo capacity of 11,200 short tons, carries crew and passengers of 184 and has a normal operating speed of 21 knots.

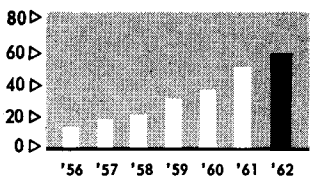
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PHYSICAL RESEARCH Cost Trends



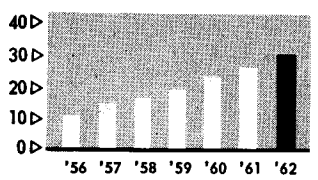
FUSION POWER RESEARCH

Costs have continued on a downward trend after reaching a peak in fiscal year 1960. This trend is primarily due to the decrease in fabrication cost of devices.



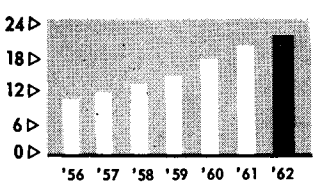
HIGH ENERGY PHYSICS

A steady increase in costs is the result of additional high energy accelerators coming into operation over the years.



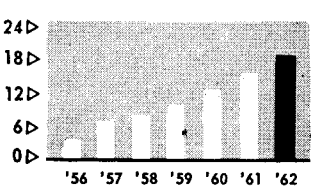
CHEMICAL PROPERTIES AND REACTIONS

Increasing emphasis has resulted in nearly tripling the cost of research on chemical properties and reactions since fiscal year 1956.



NUCLEAR STRUCTURE AND NEUTRON PHYSICS

The necessity for a more thorough knowledge of nuclear structure and neutron physics has required the continual expansion of research to the present level.



METALLURGY AND MATERIALS RESEARCH

Costs have nearly doubled since fiscal year 1959 because of the recognition of an urgent need for increased research effort in this area.

PHYSICAL RESEARCH

Investigations of the laws of nature, including neutron physics, elementary-particle physics, nuclear structures, materials-related research, and research effort to harness fusion energy were the major physical research areas in fiscal year 1962.

The following table shows a comparison of costs in major scientific areas for 1962 and 1961.

	Fiscal Year	
	1962	1961
	(in thousands)	
Fusion power research	$ 24,998	$ 30,136
High energy physics	58,676	47,521
Chemical properties and reactions	30,301	25,166
Nuclear structure and neutron physics	21,660	19,757
Metallurgy and materials research	19,065	15,344
Systems and materials chemistry	5,776	5,333
Physical and chemical methods of isotope separation	2,074	1,927
Computer research and development	3,712	3,489
Other physical research	5,520	5,432
Total	$171,782	$154,105

Fusion Power Research

In fiscal year 1962, the cost of the program leading to the future development of fusion energy for the production of power was $25 million compared to $30 million in 1961. Several different approaches to the problem are being made. The table below shows a comparison of the costs for these various approaches for 1962 and 1961.

	Fiscal Year	
	1962	1961
	(in thousands)	
Stellarator	$ 6,898	$11,040
Magnetic mirror	3,223	3,528
Direct current experiment	5,811	6,552
Relativistic electron	1,301	789
Pinch, magnetic shock compression, and rotating plasma	3,470	4,426
General research and development	4,295	3,801
Total	$24,998	$30,136

High Energy Physics

Fiscal year 1962 costs of high energy physics were $58.7 million, an increase of $11.2 million or 23 percent over 1961. The effort in high energy physics centers around attempts to learn as much as possible about the properties of fundamental nuclear particles through research with high energy particle accelerators.

The following table shows a comparison of the research and development costs incurred for 1962 and 1961 in high energy physics research.

	Fiscal Year	
	1962	1961
	(in thousands)	
In operation		
Alternating Gradient Synchrotron 33 BEV	$ 6,854	$ 4,601
Bevatron 6.2 BEV	10,546	11,466
California Institute of Technology Accelerator 1.5 BEV	1,044	731
Cambridge Accelerator 6 BEV	3,725	731
Cosmotron 3.2 BEV	4,911	5,123
184″ Cyclotron 740 MEV	2,161	1,672
	29,241	24,324
Under Construction		
Princeton-Penn Accelerator 3 BEV	3,815	3,475
Stanford Accelerator 10 to 20 BEV	3,779	3,143
Zero Gradient Synchrotron 12.5 BEV	2,911	3,014
	10,505	9,632
Other High Energy Physics Research	18,930	13,565
Total	$58,676	$47,521

BIOLOGY AND MEDICINE RESEARCH

Fiscal year 1962 costs of biomedical research were $62.8 million, an increase of $9 million or 17 percent over 1961. Increased efforts were made in environmental research required to assure the public safety from radiation hazards arising from atomic energy applications. Research activities have continued in the utilization of atomic energy (including its tools and by-products) in the biomedical and agricultural sciences.

The following table shows a comparison of costs in fields of biomedical research in 1962 and 1961:

	Fiscal Year	
	1962	1961
	(in thousands)	
Somatic effects of radiation	$16,837	$14,047
Radiation genetics	4,470	4,075
Combating detrimental effects of radiation	2,347	2,147
Molecular and cellular level studies	10,671	9,640
Environmental radiation studies	11,989	8,648
Radiological and health physics & instrumentation	4,760	4,278
Chemical toxicity	673	578
Nuclear energy civil effects	2,287	1,458
Cancer research	5,388	5,137
Selected beneficial applications	3,360	3,858
Total	$62,782	$53,866

RESEARCH LABORATORIES

A major portion of AEC research and development is conducted in government-owned laboratories. The investment in completed AEC-owned research facilities at June 30, 1962, was $1.7 billion. These facilities include research reactors, accelerators, and general laboratory buildings, equipment and research devices.

The research and development work conducted in AEC-owned laboratories includes civilian and military reactor design and development; physical research; research in the life sciences; and research to improve nuclear materials production processes and techniques. The ten laboratories shown below are the principal centers of the Commission's research effort. The operating costs of these laboratories together with the costs incurred at other AEC-owned installations and the cost of the work performed in facilities owned by universities, industrial, and other privately-owned organizations are included in the costs of the various research areas shown throughout this report.

PRINCIPAL AEC LABORATORIES

	Investment in Completed Plant June 30, 1962	Operating Costs Fiscal Year	
		1962	1961
		(in thousands)	
Los Alamos Scientific Laboratory	$178,182	$ 92,086	$ 73,997
Argonne National Laboratory	163,761	52,827	48,442
Oak Ridge National Laboratory	183,397	69,844	67,610
Brookhaven National Laboratory	122,701	34,025	29,082
Lawrence Radiation Laboratory	165,587	136,254	106,066
Bettis Atomic Power Laboratory (including Naval Reactor Facility at NRTS, Idaho)	109,193	63,502	61,038
Knolls Atomic Power Laboratory	114,082	47,753	45,221
Ames Research Laboratory	10,556	5,239	4,377
Hanford Laboratory	85,044	36,675	32,750
Savannah River Laboratory	57,681	16,808	14,314

SALE OF MATERIALS AND SERVICES

Revenue from sales of materials and services for fiscal year 1962 amounted to $20 million as compared with $16 million for fiscal year 1961. The table below shows the major sources of this income.

	Fiscal Year	
	1962	1961
	(in thousands)	
Source and special nuclear materials	$ 9,762	$ 6,575
Heavy water	4,543	5,560
Radioisotopes	1,735	1,803
Vanadium pentoxide	944	209
Other materials	472	386
Services	2,119	983
Total	$19,575	$15,516

Materials Leased

Materials with licensees and foreign governments increased to $129 million at June 30, 1962 from $127 million at June 30, 1961. These amounts represent the established value of the material. The following table compares the value of materials leased by type of organizations at June 30, 1962 and 1961. It also shows the value of such material which was subject to use charges and the value of material that was exempt from use charges. Use charges waived during fiscal year 1962 were $2.4 million. Use charges earned in 1962 were $2.9 million.

SOURCE AND SPECIAL NUCLEAR MATERIALS AND HEAVY WATER LEASED

	Total June 30		Subject to 4¾% Use Charge June 30		Not Subject to Use Charge June 30	
	1962	1961	1962	1961	1962	1961
			(in thousands)			
Domestic:						
Industrial organizations	$100,313	$105,579	$55,850	$63,587	$44,463	$41,992
Educational and research institutions	12,339	10,809	134	91	12,205	10,718
Other Federal agencies	2,138	1,225			2,138	1,225
Foreign countries	13,910	9,612	13,910	9,612		
Total	$128,700	$127,225	$69,894	$73,290	$58,806	$53,935

SALES OF RADIOISOTOPES

Radioisotope sales in fiscal year 1962 amounted to $1.7 million as compared to $1.8 million for fiscal year 1961. Foreign sales of radioisotopes increased to $328 thousand, 11 percent more than in fiscal year 1961.

The following table shows a comparison of sales of radioisotopes for fiscal years 1962 and 1961.

	Sales			
	Quantity		Dollars	
	1962	1961	1962	1961
	(curies)		*(in thousands)*	
Carbon-14	28	42	$ 229	$ 398
Polonium-210	1,903	1,035	137	94
Cesium-137	100,769	16,084	122	27
Tritium	59,540	37,034	119	75
Phosphorus-32	102	134	102	139
Cobalt-60	44,668	71,852	64	170
Krypton-85	4,007	3,696	58	60
Iridium-192	4,522	6,309	30	40
Iodine-131	132	290	43	99
Thallium-204	21	14	15	14
Chlorine	*	*	12	18
Strontium-90	1,282	256	11	3
Promethium-147	1,491	968	5	3
Technetium-99	43†	38	4	5
All other			784	658
Total			$1,735	$1,803

*Less than 1 curie.
†In grams.

Total revenue from sales of radioisotopes decreased $68 thousand in fiscal year 1962 because of reduction in prices of some radioisotopes and the increased availability of commercial supplies of iodine and cobalt.

The number of licenses granted for use of radioisotopes increased 10 percent in 1962 as compared with 1961. The following table gives a comparison of the number of licenses by type of organization:

ORGANIZATIONS WITH RADIOISOTOPE LICENSES

	June 30	
	1962	1961
Medical institutions and physicians	2,888	2,705
Industrial organizations	2,076	1,898
Federal and state laboratories	1,444	1,230
Colleges and universities	355	317
High schools, foundations, and other institutions	122	116
Total	6,885	6,266

INTERNATIONAL ACTIVITIES

The Atoms for Peace Program was established to further the objectives of U. S. foreign policy. In large part, the program is accomplished through agreements for cooperation with 37 foreign countries, the European Atomic Energy Community (EURATOM), and the International Atomic Energy Agency (IAEA). Among the activities carried out under this program the following are major items supported through funds appropriated to the AEC:

	Fiscal Year 1962 *(in thousands)*
Joint Euratom research and development	$2,582
Cooperation with Canada in research on heavy water reactors	1,431
Advisory and consultant services	52

In addition to the foregoing activities, AEC also makes materials available to foreign countries and organizations through sale or lease. In fiscal year 1962, foreign sales of heavy water amounted to $4.3 million, sales of special nuclear material amounted to $2.7 million, and sales of isotopes amounted to $.5 million.

The sales value of special nuclear material leased to foreign organizations was $9.5 million and the heavy water leased had a sales value of $4.4 million.

Education and training for foreign nationals is summarized on page 24.

INTERNATIONAL SCIENTIFIC NUCLEAR ENERGY EXHIBITS

International scientific nuclear energy exhibits are comprehensive presentations for demonstrating to overseas scientific and public audiences many of the peaceful applications of atomic energy.

The following table shows the location, estimated attendance and cost of each of the thirteen major overseas exhibits presented to date:

Location	Estimated Attendance	Total Cost *(in thousands)*
Geneva, Switzerland I	63,000	$1,699
Geneva, Switzerland II	100,000	4,357
Rome, Italy	83,000	206
Tokyo, Japan	800,000	321
New Delhi, India	2,850,000	342
Cairo, UAR	137,000	298
Lahore, Pakistan	245,000	135
Buenos Aires, Argentina	150,000	633
Rio de Janeiro, Brazil	200,000	217
Lima, Peru	77,000	243
Beirut, Lebanon	70,000	166
Mexico City, Mexico	147,000	216
Athens, Greece	80,000	150

INDEMNIFICATION

Public Law 85-256, section 170 of the Atomic Energy Act of 1954, provides a means of protecting the public from financial loss due to a catastrophic nuclear incident arising out of the operation of certain nuclear facilities. Since the total loss from such an incident might greatly exceed the amount of private insurance available ($60 million), the AEC is authorized to enter into indemnification agreements with some of its licensees providing public liability protection of $500 million for each incident.

Except for non-profit educational institutions and Federal agencies, the operator of a licensed nuclear facility is required to provide some financial protection in order to qualify for the indemnification. The exact amount of financial protection depends on the purpose of the reactor operated, its location in terms of population density, and the power level.

As of June 30, 1962, there were in effect 66 indemnity agreements. To provide the indemnity protection, AEC charges $30 a megawatt, subject to a minimum annual charge of $100. Revenue from the fees in 1962 was $47 thousand.

The following table summarizes the indemnity agreements entered into by AEC, the reactor power level, and the amount of financial protection required of the licensee in order to qualify for the indemnification:

INDEMNITY AGREEMENTS

Organization	Power Level (Thermal)	Financial Protection Required
Yankee Atomic Electric Co.	485,000 KW	$60,000,000
Commonwealth Edison Company	630,000 KW	60,000,000
Consolidated Edison Company	585,000 KW	60,000,000
Westinghouse Electric Corporation	60,000 KW	12,600,000
General Electric Company	{50,000 KW 33,000 KW}	12,000,000
Battelle Memorial Institute	2,000 KW	2,500,000
Industrial Reactor Laboratories, Inc. & Columbia University	5,000 KW	2,500,000
Union Carbide Corporation	5,000 KW	2,500,000
Armour Research Foundation of Illinois Institute of Technology	75 KW	1,500,000
Babcock & Wilcox Company	450 KW	1,500,000
General Dynamics Corporation	1,000 KW	1,500,000
Saxton Nuclear Experimental Corporation	200 KW	1,500,000
Aerojet-General Nucleonics	20 W	1,000,000
Alco Products, Inc.	100 W	1,000,000
Allis-Chalmers Manufacturing Co.	100 W	1,000,000
American Radiator & Standard Sanitary Corporation	15 W	1,000,000
Martin-Marietta Corporation	50 W	1,000,000
North American Aviation, Inc.	200 W	1,000,000
Power Reactor Development Co.		1,000,000
United Nuclear Corporation	5 W	1,000,000
46 Educational Institutions and Federal Agencies		None

EDUCATION AND TRAINING

Financial assistance to colleges, universities, teachers and students, for the purpose of encouraging interest in the curriculum and courses offered in the field of atomic energy, amounted to $8.6 million in fiscal year 1962. In addition, the AEC has materials on loan to educational institutions valued at $12.2 million on which use charges of $.5 million are waived.

	Fiscal Year 1962 *(in thousands)*
Grants for the purchase of equipment to 228 colleges and universities	$2,400
Operation of schools and courses	3,149
Training institutes – 828 teachers	1,335
Fellowships – 250 fellows	1,400
Other costs	353
	$8,637
Waiver of use charges	543
Total	$9,180

Operation of schools and courses. The following table shows the number of enrollments and the cost of operating schools and courses in the field of nuclear technology.

	Number of Enrollments		Net Operating Cost Fiscal Year 1962
	Foreign	Domestic	*(in thousands)*
Schools:			
International Institute of Nuclear Science and Engineering – ANL	172	12	$ 846
Puerto Rico Nuclear Center	23	143	1,579
Courses:			
Reactor Supervisors Training – Shippingport	11	2	–
Reactor Operations Supervision – ORNL	4	14	80
Reactor Hazards Evaluation – ORNL	6	16	82
Radioisotopes Training – ORINS	33	310	282
Science Lecture Demonstration Program – ORINS		35	60
Mobile Isotope Training – ORINS		144	42
Training for State and Local Government Employees		27	39
Total			$3,010*

*After deducting revenue of $139 thousand.

RESEARCH ON USES OF ISOTOPES

Fiscal year 1962 cost of research to develop uses of radioisotopes and high level radiation was $6.3 million, an increase of $2.7 million or 75 percent over 1961. The following table shows the cost of the areas of research for 1962 and 1961:

	Fiscal Year	
	1962	1961
	(in thousands)	
Radioisotope technology	$1,984	$1,275
Radioisotope process research and production development	1,396	1,058
Process radiation	1,512	1,142
Isotopic power fuel development	1,058	*
Food pasteurization	356	180
Total	$6,306	$3,655

*Included in reactor development in 1961.

FOOD PRESERVATION

AEC is conducting research to establish the feasibility of extending the refrigerated storage life of selected marine products and fruits by radiation pasteurization. The studies are both from the standpoint of utilization of high level radiation and the effect such radiation has on the material itself. The high level radiation research portion is shown in the table above. The biological portion cost $177,000 in fiscal year 1962 and $88,000 in fiscal year 1961. The combined cost of this effort was $533,000 in 1962 as compared to $268,000 for 1961.

COSTS INCURRED BY AEC PRIME CONTRACTORS BY LOCATION

The following table shows the costs incurred by AEC in fiscal year 1962 in the various states. Allocations of cost to the states are made in accordance with the physical location of the contractors but do not necessarily represent funds spent in those states.

State	Operating Costs*	Plant Acquisition and Construction	Total
		(in thousands)	
Alabama	$ 160	$	$ 160
Alaska	31		31
Arizona	3,188		3,188
Arkansas	265		265
California	299,459	15,832	315,291
Colorado	79,885	5,013	84,898
Connecticut	36,338	66	36,404
Delaware	114	20	134
District of Columbia	21,232	49	21,281
Florida	18,016	22	18,038
Georgia	718		718
Hawaii	2,056		2,056
Idaho	41,301	22,748	64,049
Illinois	72,074	25,537	97,611
Indiana	2,030	358	2,388
Iowa	16,595	1,365	17,960
Kansas	653		653
Kentucky	89,051	813	89,864
Louisiana	192		192
Maine	183		183
Maryland	32,765	670	33,435
Massachusetts	27,596	1,227	28,823
Michigan	3,084		3,084
Minnesota	1,411	1,109	2,520
Mississippi	1,622		1,622
Missouri	110,652	1,798	112,450
Montana	49		49
Nebraska	2,485	4,311	6,796
Nevada	141,975	18,038	160,013
New Hampshire	115		115
New Jersey	18,883	6,616	25,499
New Mexico	421,602	14,549	436,151
New York	106,390	14,492	120,882
North Carolina	1,217		1,217
North Dakota	18		18
Ohio	138,519	5,392	143,911
Oklahoma	613		613
Oregon	6,875		6,875
Pennsylvania	65,658	3,653	69,311
Rhode Island	505		505
South Carolina	95,878	17,195	113,073
South Dakota	5,670		5,670
Tennessee	231,719	35,911	267,630
Texas	22,321	1,101	23,422
Utah	47,881		47,881
Vermont	37		37
Virginia	6,821		6,821
Washington	114,762	75,613	190,375
West Virginia	95		95
Wisconsin	4,050	427	4,477
Wyoming	46,075		46,075
Foreign countries	270,609	3,216	273,825
Total	$2,611,493	$277,141	$2,888,634

*Includes equipment but excludes depreciation.

UNITED STATES ATOMIC BALANCE

ASSETS

	June 30, 1962	June 30, 1961
	(in thousands)	
FUNDS IN U. S. TREASURY	$1,204,549	$1,462,842
ALLOCATIONS FROM OTHER FEDERAL AGENCIES	33,008	52,001
CASH ON HAND AND WITH CONTRACTORS	29,637	21,498
ACCOUNTS RECEIVABLE	14,250	14,344
DUE FROM OTHER FEDERAL AGENCIES	32,248	13,068
INVENTORIES		
Source and nuclear materials leased and at research installations	613,073	497,616
Special reactor material	105,430	101,899
Stores	93,949	91,885
Isotopes	16,925	13,420
Other special materials	15,920	19,856
	845,297	724,676
PLANT		
Completed plant and equipment	7,364,671	7,201,938
Less – Accumulated depreciation	2,293,890	2,209,028
	5,070,781	4,992,910
Construction work in progress	504,579	462,798
	5,575,360	5,455,708
PREPAYMENTS AND SPECIAL DEPOSITS	68,873	58,258
TOTAL ASSETS	$7,803,222	$7,802,395

ENERGY COMMISSION
SHEET

LIABILITIES AND AEC EQUITY

	June 30, 1962	June 30, 1961
	(in thousands)	
LIABILITIES		
Accounts payable and accrued expenses	$ 287,941	$ 267,127
Advances from other Federal agencies	45,012	55,982
Funds held for others	14,376	11,758
Accrued annual leave of AEC employees	7,032	6,989
Deferred credits	1,730	2,334
TOTAL LIABILITIES	356,091	344,190
AEC EQUITY, JULY 1	7,458,205	7,316,702
Additions		
Funds appropriated—net	2,547,338	2,666,760
Nonreimbursable transfers from other Federal agencies	7,341	8,393
	2,554,679	2,675,153
Deductions		
Net cost of operations (less charges to inventories of $142,388 thousand in 1962 and $114,958 thousand in 1961)	2,478,232	2,497,803
Nonreimbursable transfers to other Federal agencies	87,445	35,296
Funds returned to U. S. Treasury	76	551
	2,565,753	2,533,650
AEC EQUITY, JUNE 30	7,447,131	7,458,205
TOTAL LIABILITIES AND AEC EQUITY	$7,803,222	$7,802,395

The notes on the following page are an integral part of this statement.

NOTES TO THE BALANCE SHEET

1. The balance sheet does not include in assets:

   a. Certain inventories for security reasons.

   b. 64,751,316 troy ounces of silver loaned to AEC by the Treasurer of the United States for use as electrical conductors in plants. Of this amount, 280,500 troy ounces have been lost in usage and are therefore not returnable. Based on market quotations at June 30, 1962, the value of the silver on hand was $67,600,000. The cost of silver lost and the cost of recovering and processing that on hand and returning it to the Treasury is estimated at $607,600.

   c. Plant and equipment on loan from other Federal agencies at June 30, 1962, amounting to $37,000,000.

   d. Contested claims against others of $787,000.

2. The balance sheet does not include in liabilities:

   a. Contingent liabilities related to contracts for the supply of electric power and natural gas for the Oak Ridge, Paducah and Portsmouth production facilities. If cancellation notice had been given at June 30, 1962, the estimated liabilities would have amounted to $281,000,000.

   b. Contingent liabilities as guarantor of loans to the extent of $41,300,000.

   c. Contingent liabilities for claims against AEC of approximately $18,000,000.

   d. Under provisions of Section 66 of the Atomic Energy Act of 1954, AEC has guaranteed minimum prices for concentrates for the period April 1, 1962 to December 31, 1966. Subject to certain limitations, a price of $8 per pound has been established for U_3O_8 in concentrates delivered before December 31, 1966. The Commission also has long-term commitments through 1966 for the purchase of U_3O_8 in concentrates and orange oxide from Canadian and overseas sources. The commitments for procurement of uranium totaled $1,626,000,000 at June 30, 1962.

   e. Commitments under Section 52 of the Atomic Energy Act of 1954 for the acquisition of special nuclear material within or under the jurisdiction of the United States. The amount of the commitments is $5,000,000 at June 30, 1962, based upon estimates (at the price established for the period ending June 30, 1963) of plutonium to be produced and delivered by domestic licensees during the period for which prices have been established.

   f. Outstanding contracts, purchase orders and other commitments represented by unpaid obligations of $935,000,000.

UNITED STATES ATOMIC ENERGY COMMISSION
STATEMENT OF OPERATIONS

	Fiscal Year Ended	
	June 30, 1962	June 30, 1961
	(in thousands)	
Production		
Procurement of raw materials	$ 537,363	$ 636,832
Production of nuclear materials	688,533	732,524
Weapons development and fabrication	705,893	512,317
	1,931,789	1,881,673
Development of nuclear reactors		
Civilian nuclear power development	94,320	102,305
Naval propulsion	95,375	93,442
Army reactors	12,844	13,532
Aircraft propulsion		71,116
Missile propulsion	21,466	23,080
Space propulsion	42,455	25,143
Auxiliary power sources	53,572	21,316
Merchant ships	9,045	5,341
General research and development	104,073	81,999
	433,150	437,274
Research		
Physical research	171,782	154,105
Biology and medicine research	62,782	53,866
Peaceful application of nuclear explosives	9,329	7,311
Isotope development	6,306	3,655
	250,199	218,937
Community operations		
Expenses	10,283	10,143
Revenues	(5,851)	(5,680)
	4,432	4,463
Sales of materials and services		
Cost	17,311	13,120
Revenue	(19,575)	(15,516)
	(2,264)	(2,396)
Education and training	8,637	8,867
AEC administrative expenses	60,592	57,709
Security investigations	7,748	6,467
Other expenses	9,927	8,214
Other income	(8,274)	(8,299)
Net cost of operations*	2,695,936	2,612,909
Special items		
Adjustments to costs of prior years—net	(75,316)	(1,474)
Transfer of community property		1,326
Net cost of operations—after special items	$2,620,620	$2,612,761

*Includes depreciation of $289 million in 1962 and $287 million in 1961.

U. S. GOVERNMENT INVESTMENT IN THE ATOMIC ENERGY PROGRAM

(from June 1940 through June 1962)

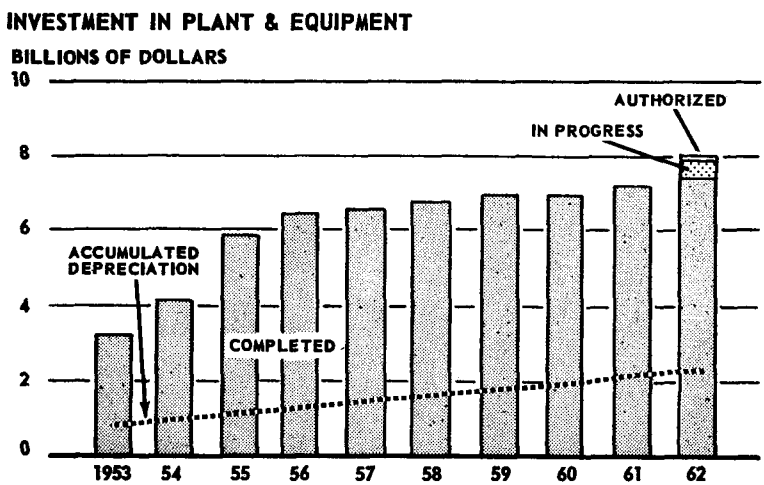
		(in millions)
Appropriation Expenditures:		
National Defense Research Council	$ .5	
Office of Scientific Research and Development	14.6	
War Department (including Manhattan Engineer District)	2,218.3	
		$ 2,233.4
Atomic Energy Commission		
Fiscal Years Prior to 1953	4,375.2	
Fiscal Year 1953	1,812.7	
Fiscal Year 1954	1,930.5	
Fiscal Year 1955	1,861.8	
Fiscal Year 1956	1,633.5	
Fiscal Year 1957	1,931.5	
Fiscal Year 1958	2,268.0	
Fiscal Year 1959	2,541.2	
Fiscal Year 1960	2,622.8	
Fiscal Year 1961	2,713.5	
Fiscal Year 1962	2,805.7	
		26,496.4
Total		28,729.8
Unexpended balance of funds in U. S. Treasury June 30, 1962		1,204.5
Total funds appropriated		29,934.3
Less		
Collections paid to U. S. Treasury	54.7	
Property and services transferred to other Federal agencies without reimbursement, net of such transfers received from other Federal agencies	252.8	
Cost of operations (including depreciation and obsolescence) from June 1940 through June 30, 1962	22,179.7	
		22,487.2
AEC Equity at June 30, 1962, as shown on Balance Sheet		$ 7,447.1

PLANT AND EQUIPMENT

AEC-owned plant and equipment includes plants for the preparation of feed materials; gaseous diffusion plants for the separation of the fissionable isotope uranium-235 from the stable isotope uranium-238; reactors for the production of plutonium, isotopes and other reactor products; facilities for the fabrication and test of weapons; reactors for testing materials and equipment components; reactor prototypes; and research laboratories. Completed plant, at cost, amounted to $7,365 million at June 30, 1962 – $163 million more than at June 30, 1961.

The estimated cost of plant under construction and projects authorized but not started at June 30, 1962, totaled $1,225 million. Costs incurred through June 30, 1962, on plant under construction amounted to $505 million, leaving the estimated costs to be incurred subsequent to June 30, 1962, at $721 million. A major portion of this authorized plant expansion is for construction of reactors and related facilities and for facilities to be used in high energy and controlled thermonuclear research.

The chart below shows the investment in completed plant and the accumulated depreciation for each fiscal year from 1953 through 1962. For 1962, the chart also shows the costs incurred on partially completed plant projects as well as the estimated cost of projects authorized for construction or completion in subsequent years.



INVESTMENT IN PLANT AND EQUIPMENT BY TYPE OF FACILITY

June 30, 1962

	Completed Plant	Construction in Progress	Total
		(in thousands)	
Production			
Raw Materials	$ 3,477	$ 13	$ 3,490
Feed materials	276,562	6,584	283,146
Gaseous diffusion plants	2,348,358	5,760	2,354,118
Production reactors and separations areas	1,583,941	162,780	1,746,721
Weapons production and storage	723,774	28,509	752,283
Heavy water	163,683	81	163,764
Other production facilities	244,728	2,966	247,694
Total production	5,344,523	206,693	5,551,216
Research and development			
Laboratories	1,029,983	61,625	1,091,608
Reactors	462,638	183,387	646,025
Accelerators	170,634	43,269	213,903
Other research facilities	50,731	2,858	53,589
Total research	1,713,986	291,139	2,005,125
Communities	77,013	3,142	80,155
Other	229,149	3,605	232,754
Total	$7,364,671	$504,579	$7,869,250

Changes in investment in plant and equipment during the fiscal year are as follows:

	Completed Plant	Construction in Progress	Total
		(in thousands)	
Investment–June 30, 1961	$7,201,938	$462,798	$7,664,736
Construction and equipment costs		423,766	423,766
Additions to completed plant	381,985	(381,985)	
Plant retirements	(62,699)		(62,699)
Sale of community facilities by HHFA	(1,483)		(1,483)
Transfers to other Federal agencies	(155,070)		(155,070)
Investment–June 30, 1962	$7,364,671	$504,579	$7,869,250

AEC PLANT AND EQUIPMENT BY LOCATION

(at cost)

June 30, 1962

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
CALIFORNIA				
Lawrence Radiation Laboratory, University of California				
Berkeley	$ 52.8	$ 17.9	$ 3.5	$ 74.2
Livermore	109.5	3.6	11.0	124.1
Research facilities, Sandia Corporation, Livermore	13.5	.8	.8	15.1
Medical research facilities University of California, Los Angeles	1.2			1.2
Salton Sea Base, Sandia Corporation, Salton Sea	5.0			5.0
Research facilities, California Institute of Technology, Pasadena	2.4			2.4
Linear Electron Accelerator, Stanford University, Palo Alto	1.4	114.0		115.4
Reactor and research facilities, Atomics International Division, North American Aviation, Inc., Canoga Park	25.2	13.2		38.4
Computer facilities, University of California, La Jolla	1.2			1.2
Research facilities, Holmes and Narver, Inc., Los Angeles	1.5			1.5
COLORADO				
Uranium handling, sampling and general facilities, Lucius Pitkin, Inc., Grand Junction	4.6	.1		4.7
Rocky Flats Plant, Dow Chemical Company, Boulder	81.1	10.3	6.6	98.0
CONNECTICUT				
Pratt and Whitney, Middletown	5.2	.1	1.7	7.0
Linear accelerators, Yale University, New Haven	3.9			3.9
Submarine reactor facilities, Combustion Engineering, Inc., Windsor	14.6	.4		15.0
FLORIDA				
Pinellas Plant, General Electric Company, Clearwater	12.3	.2		12.5

Location and Contractor	Completed Plant and Equipment	Estimated Total cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
IDAHO				
National Reactor Testing Station				
Phillips Petroleum Company				
Chemical processing plant	$ 59.8	$ 4	$	$ 60.2
Advanced test reactor		47.0		47.0
Materials test reactor	15.5	.5		16.0
Engineering test reactor	13.3	.1		13.4
MTR-ETR facilities	14.8	1.9		16.7
Reactor facilities	34.3	19.2	5.1	58.6
General facilities	22.0	3.3	1.6	26.9
Total	159.7	72.4	6.7	238.8
Westinghouse Electric Corporation				
Large ship reactor	35.6	.8		36.4
Submarine thermal reactor	14.3	.2		14.5
Other research facilities	10.4	1.9		12.3
Total	60.3	2.9		63.2
Research facilities, General Electric Company	20.3	.9		21.2
Reactor facilities, Argonne National Laboratory	7.6	32.1	.1	39.8
Knolls Atomic Power Laboratory, General Electric Company	1.6	18.5		20.1
Organic moderated reactor experiment, North American Aviation, Inc.	2.2	.7		2.9
Experimental Beryllium Oxide Reactor, General Atomics			8.0	8.0
Total National Reactor Testing Station	251.7	127.5	14.8	394.0
ILLINOIS				
Argonne National Laboratory, University of Chicago, Argonne	156.2	60.9	9.7	226.8
Argonne Cancer Research Hospital, University of Chicago, Chicago	4.9	.1		5.0
INDIANA				
Radiation Laboratory, University of Notre Dame, Notre Dame	.4	2.2		2.6

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
IOWA				
Research Laboratory, Iowa State College, Ames	$ 10.6	$ 5.2	$ .3	$ 16.1
Iowa Ordnance Plant, Mason and Hanger, Burlington	33.4	.6	.2	34.2
KENTUCKY				
Paducah				
Gaseous Diffusion Plant, Union Carbide Nuclear Company	756.7	2.2		758.9
Feed Materials Plant, Union Carbide Nuclear Company	26.3	1.0		27.3
Total	783.0	3.2		786.2
MARYLAND				
AEC Headquarters, Germantown	18.6			18.6
MASSACHUSETTS				
Cambridge electron accelerator, Harvard University, Cambridge	13.7	.2	.3	14.2
Research facilities, Edgerton, Germeshausen & Grier, Inc., Boston	4.7	.6		5.3
Research facilities, Massachusetts Institute of Technology, Cambridge	2.0	.3		2.3
MICHIGAN				
Organic reactor project			20.0	20.0
MINNESOTA				
Linear accelerator, University of Minnesota, Minneapolis	2.0			2.0
Boiling water power reactor, Rural Cooperative Power Association, Elk River		10.8		10.8
MISSOURI				
Kansas City Plant, The Bendix Corporation, Kansas City	42.0	5.2	2.2	49.4
Feed Materials Plant, Mallinckrodt Chemical Works, Weldon Spring	59.5	.9	1.6	62.0
NEBRASKA				
Sodium graphite power reactor, Consumers Public Power District, Hallam		30.8		30.8
NEVADA				
Mercury				
Nevada Test Site, Reynolds Electrical and Engineering, Co., Inc.	69.9	29.0	17.3	116.2

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
NEVADA (Cont'd)				
Nevada Test Site, Edgerton, Germeshausen & Grier, Inc.	$ 2.8	$	$	$ 2.8
Research facilities, University of California	5.0	2.1		7.1
Laboratory facilities, Lawrence Radiation Laboratory	3.2	12.3		15.5
Total Mercury	80.9	43.4	17.3	141.6
Tonopah				
Research facilities, Reynolds Electrical and Engineering Company	1.3	3.2		4.5
Research facilities, Sandia Corporation	4.8			4.8
Total Tonopah	6.1	3.2		9.3
NEW JERSEY				
New Brunswick Laboratory, Atomic Energy Commission, New Brunswick	2.1	.1		2.2
Princeton				
Princeton–Pennsylvania proton accelerator, Princeton University	15.7	11.0	.9	27.6
Model C stellarator facilities, Princeton University	14.2	.3		14.5
Total Princeton	29.9	11.3	.9	42.1
NEW MEXICO				
Albuquerque				
Lovelace Foundation Laboratory	.3	2.0		2.3
Sandia Laboratory, Sandia Corporation	92.5	9.5	7.4	109.4
South Albuquerque Works, ACF Industries, Inc.	24.9	.2		25.1
Total Albuquerque	117.7	11.7	7.4	136.8
Los Alamos				
Los Alamos Scientific Laboratory, University of California	173.2	23.4	4.0	200.6
Community and general maintenance facilities, The Zia Company	132.8	5.4	1.9	140.1
Los Alamos Hospital, Los Alamos Medical Center, Inc.	2.9			2.9
Total Los Alamos	308.9	28.8	5.9	343.6

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
NEW YORK				
Brookhaven National Laboratory, Associated Universities, Inc., Upton	$ 122.7	$ 44.4	$ 10.6	$ 177.7
New York City				
Computing and other research facilities, New York University	1.7			1.7
Accelerator and research facilities, Columbia University	2.9			2.9
Health and Safety Laboratory	1.9			1.9
Total New York City	6.5			6.5
Boron plant, Olin Mathieson Chemical Corporation, Niagara Falls	7.5			7.5
Research Laboratory, University of Rochester, Rochester	5.7			5.7
Knolls Atomic Power Laboratory, General Electric Company,				
Schenectady	43.2	.8		44.0
West Milton	69.3	1.5	.9	71.7
Fuel Preparation Areas, Sylvania Electric Products Inc., Hicksville	2.3	.1		2.4
Accelerator facility, Rensselaer Polytechnic Institute, Troy	2.2			2.2
OHIO				
Research facilities, General Electric Company, Cincinnati	7.4			7.4
Bridgeport Brass Company, Ashtabula	1.2	.1		1.3
Portsmouth				
Portsmouth Gaseous Diffusion Plant, Goodyear Atomic Corporation	754.8	1.4		756.2
Feed Materials Plant, Goodyear Atomic Corporation	7.9			7.9
Total Portsmouth	762.7	1.4		764.1
Feed Materials Plant, National Lead Company, Fernald	115.0	4.8		119.8
Mound Laboratory, Monsanto Chemical Company, Miamisburg	34.7	4.2	1.4	40.3
Organic moderated power reactor, City of Piqua, Piqua		8.1		8.1

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
PENNSYLVANIA				
Bettis plant, Westinghouse Electric Corporation, Pittsburgh	$ 48.8	$ 1.7	$	$ 50.5
Accelerator and research facilities, Carnegie Institute of Technology, Pittsburgh	1.3			1.3
Pressurized water reactor, Duquesne Light Company, Shippingport	50.5	11.6	1.1	63.2
SOUTH CAROLINA				
Savannah River Plant, E. I. du Pont de Nemours and Co., Inc., Aiken				
Production reactor facilities	599.0	17.5	15.2	631.7
Separations facilities	269.8	18.6	8.9	297.3
Feed materials production facilities	30.4	1.3		31.7
Heavy water production facilities	162.8	.1		162.9
Works laboratory	57.7	1.8		59.5
General facilities	167.8	3.6	1.1	172.5
Total	1,287.5	42.9	25.2	1,355.6
TENNESSEE				
Oak Ridge				
Research Laboratory, Oak Ridge Institute of Nuclear Studies	3.9	.2		4.1
Agriculture Research Laboratory and Farm, University of Tennessee	1.7	.2		1.9
Experimental Gas Cooled Reactor	.5	51.6	2.0	54.1
Oak Ridge Gaseous Diffusion Plant, Union Carbide Nuclear Company	844.6	5.3	9.3	859.2
Fabrication and development facilities, Union Carbide Nuclear Company	400.8	12.7	4.4	417.9
Oak Ridge National Laboratory, Union Carbide Nuclear Company	183.4	41.0	1.4	225.8
Service facilities	20.4	2.8		23.2
Total	1,455.3	113.8	17.1	1,586.2
TEXAS				
Pantex Plant, Mason and Hanger, Amarillo	28.8	1.2		30.0
Medina facility, Mason and Hanger, San Antonio	17.2	.3		17.5

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
UTAH				
Monticello				
Uranium ore processing plant, Lucius Pitkin, Inc.	$ 3.3	$	$	$ 3.3
Community services, Lucius Pitkin, Inc.	.3			.3
Total	3.6			3.6
WASHINGTON				
Hanford Works, General Electric Company, Hanford				
Production reactor facilities	480.0	197.5	6.0	683.5
Separations facilities	173.9	9.8	.2	183.9
Feed materials production facilities	26.2			26.2
Works laboratory	85.0	9.7	1.2	95.9
General facilities	161.1	6.7	5.5	173.3
Total	926.2	223.7	12.9	1,162.8
Community services, General Electric Company, Richland	1.3			1.3
WEST VIRGINIA				
Huntington pilot plant, International Nickel Company, Huntington	4.7			4.7
WYOMING				
Army Package Power Reactor No. 2, The Martin Company, Sundance	4.0			4.0
ANTARCTICA				
Power Reactor Plant, Allis Chalmers Mfg. Co., Byrd Station		7.0		7.0
PUERTO RICO				
Puerto Rico Nuclear Center, University of Puerto Rico, Mayaguez	4.6			4.6
Nuclear superheat power reactor, Punta Higuera	.1	9.9		10.0
JAPAN				
Research facilities, National Academy of Science, Hiroshima	2.1	.2		2.3
ALL OTHER				
Cooperative Power Demonstration Reactor Program			47.9	47.9
Weapons storage facilities	24.8	.1		24.9
N. S. *Savannah*	24.8	2.3		27.1
Other	35.0	1.7	14.4	51.1
Total	$7,364.7	$989.4	$235.7	$8,589.8

UNITED STATES ATOMIC ENERGY COMMISSION

(in

	1962	1961	1960	1959
Cost of operations	$2,695,936	$2,612,909	$2,619,143	$2,496,648
Procurement of raw materials	537,363	636,832	716,507	699,996
Production of nuclear materials	688,533	732,524	731,348	713,247
Weapons development and fabrication	705,893	512,317	505,448	491,981
Development of nuclear reactors	433,150	437,274	399,252	355,600
Civilian	94,320	102,305	100,095	78,333
Military	129,685	201,170	186,745	180,321
Space propulsion	42,455	25,143	15,462	14,011
Other	166,690	108,656	96,950	82,935
Physical research	171,782	154,105	132,845	112,318
Fusion power	24,998	30,136	32,148	27,685
High energy physics	58,676	47,521	32,263	27,517
Other	88,108	76,448	68,434	57,116
Biology and medicine research	62,782	53,866	48,878	42,781
Community operations – net	4,432	4,463	7,090	9,892
Administrative expenses	60,592	57,709	51,197	50,135
Miscellaneous expenses and income – net	31,409	23,819	26,578	20,698
Plant construction and equipment costs incurred during the year	$ 423,765	$ 432,688	$ 331,516	$ 298,979
Total AEC assets excluding inventories of certain products at June 30	$7,803,222	$7,802,395	$7,689,385	$7,764,770
Plant investment at June 30 (gross)	$7,869,250	$7,664,736	$7,344,751	$7,292,784
Production plants	5,344,523	5,453,568	5,458,201	5,552,646
Research and development facilities	1,713,986	1,434,967	1,271,253	1,124,543
Other	306,162	313,403	288,608	365,838
Plant construction in progress at June 30	504,579	462,798	326,689	249,757
Funds appropriated – net	$2,547,338	$2,666,760	$2,649,614	$2,635,335
Operations	2,352,001	2,456,210	2,387,114	2,385,406
Plant acquisition and construction	195,337	210,550	262,500	249,929
Appropriation expenditures	2,805,700	2,713,465	2,622,838	2,541,181
Employment at June 30	126,623	122,989	122,718	121,928
AEC employees	6,863	6,846	6,907	6,855
Operating contractor employees	106,394	103,313	104,612	105,195
Construction contractor employees	13,366	12,830	11,199	9,878

* Includes transfer to operations of $571 million appropriated in prior years as plant and equipment.

TEN-YEAR SUMMARY OF FINANCIAL DATA

thousands)

1958	1957	1956	1955	1954	1953
$2,298,589	$1,918,258	$1,607,973	$1,289,535	$1,039,178	$ 904,596
596,391	397,813	278,946	193,586	142,793	82,153
750,178	762,815	730,972	588,445	409,735	318,255
443,536	337,183	280.765	258,706	250,025	257,488
306,225	255,667	168,853	114,557	99,334	104,091
52,532	41,996	33,480	21,364	16,203	6,401
173,141	158,366	96,984	53,011	42,010	53,209
8,190	8,832	4,147			
72,362	46,473	34,242	40,182	41,121	44,481
87,719	69,657	56,547	48,221	43,630	41,846
19,012	11,128	7,066	4,718	1,741	800
19,146	17,595	11,981	8,583	7,802	8,644
49,561	40,934	37,500	34,920	34,087	32,402
35,958	33,148	29,849	28,898	26,974	26,295
11,162	8,897	8,954	10,321	11,822	15,157
46,435	38,499	38,195	34,027	34,671	35,514
20,985	14,579	14,892	12,774	20,194	23,797
$ 289,744	$ 317,022	$ 301,682	$ 842,504	$1,215,141	$1,125,579
$7,652,784	$7,397,911	$7,368,272	$8,077,836	$8,144,414	$8,014,455
$7,110,797	$6,907,896	$6,713,061	$6,487,301	$5,705,405	$4,579,089
5,494,440	5,392,464	5,212,776	4,645,750	2,957,784	2,118,137
937,682	792,633	753,468	707,107	616,548	548,009
407,529	411,582	499,793	505,492	515,939	483,367
271,146	311,217	247,024	628,952	1,615,134	1,429,576
$2,333,974	$1,898,700	$ 834,227	$1,209,860	$1,042,492	$4,136,476
2,225,470	1,740,400	1,146,400*	1,098,978	886,483	808,935
108,504	158,300	(312,173)*	110,882	156,009	3,327,541
2,267,960	1,931,485	1,633,549	1,861,875	1,930,536	1,812,678
121,059	119,455	110,197	112,618	142,021	148,846
7,107	6,910	6,637	6,076	6,195	6,941
103,290	98,176	90,238	82,936	73,312	71,775
10,662	14,369	13,322	23,606	62,514	70,130