UNITED STATES ATOMIC ENERGY COMMISSION

Annual Report to Congress

OF THE

ATOMIC ENERGY COMMISSION

FOR

1969

January 1970

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C.

LETTER OF SUBMITTAL

WASHINGTON, D.C.,
January 31, 1970.

SIRS: We have the honor to submit herewith the Annual Report of the United States Atomic Energy Commission for 1969 as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
JAMES T. RAMEY.
WILFRID E. JOHNSON.
THEOS J. THOMPSON.
CLARENCE E. LARSON.
GLENN T. SEABORG, *Chairman.*

The Honorable
The President of the Senate.
The Honorable
The Speaker of the House of Representatives.

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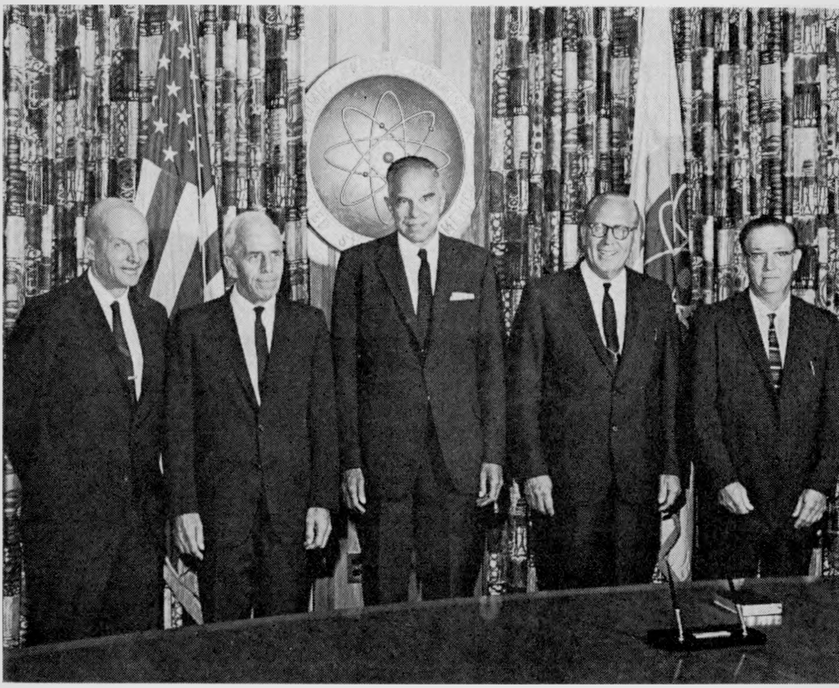

The Atomic Energy Commission. The five-man Atomic Energy Commission, reading *left* to *right*, are: Commissioner Theos J. Thompson, Commissioner Wilfrid E. Johnson, Chairman Glenn T. Seaborg, Commissioner Clarence E. Larson, and Commissioner James T. Ramey. Drs. Thompson and Larson were named by President Nixon to fill two existing vacancies on the Commission during 1969. (Commissioner Francesco Costagliola's term expired June 30, and Commissioner Gerald F. Tape resigned as of April 30 to become President of Associated Universities, Inc.) Dr. Thompson was sworn in as an AEC member on June 12, and Dr. Larson was sworn in on September 2, 1969. Officiating in both these ceremonies was Dr. Seaborg, who on March 1, 1969, started his ninth year as Chairman. Dr. Seaborg has held that post longer than any other person in the AEC's 23-year history serving Presidents Kennedy, Johnson, and Nixon.

An Introduction To:

THE ATOMIC ENERGY PROGRAM DURING 1969

The year 1969 presented a many-faceted picture of the Nation's atomic energy program. It was a year in which the blessings of the atom's inherent energy were praised and criticized; a year in which the atom's energy was used not only to help unlock the secrets of the Moon but also to enhance recovery of the Earth's hidden natural resources; a year in which the growth in nuclear energy so urgently needed to meet the power requirements of the future was incongruously slowed down by public apprehension, construction delays, and difficulties in plant equipment manufacturing capacity. It was also the year in which the world's two great nuclear Nations continued to advance the peaceful aspects of the atom and took the necessary steps toward final ratification of the Non-Proliferation Treaty.

The nuclear power industry continued to grow on many fronts. New exploration disclosed additional supplies of raw uranium ore to meet the industrial needs of the future. Toll enriching services in the AEC's gaseous diffusion plants became available on January 1, 1969, to domestic and foreign customers. New orders for nuclear plants remained low, following the normal cyclical pattern of the utility industry in ordering new generating capacity. However, mounting slippages in fabrication work and a backlog of orders forced U.S. industry to "farm out" some work on reactor pressure vessels to foreign manufacturers.

Nuclear Power Growth

The year was marked by operational starts of three new nuclear powerplants with a combined output of 1,435 megawatts of electricity (Mwe.); this was but a forerunner of 1970, when 10 of the "post-1965" ordered plants are scheduled to add 7,235 Mwe. to meet the Nation's mounting power needs. Table 1 (at end of this Introduction) shows that as of the end of 1969, there were 15 operable central station nuclear powerplants with a capacity of 3,482 Mwe., and another 82, with a combined output of about 70,000 Mwe., either under construction or under contract. Seven new units were ordered during 1969. Within 10 years, the nuclear generating capacity is projected to be in the neighborhood of 150,000 Mwe. This nuclear generating capacity will be a significant part (about 25%) of the total capacity required to meet the Nation's needs—an estimated 600,000 megawatts by 1980 from all sources.

Public Concern

The total U.S. consumption of electric power by the year 2000 is expected to be at least several times that of the 1965 level—the year of the great Northeast power blackout—and it is to the nuclear powerplant that much thought is being given by the utility industry for meeting future power requirements. Ironically, the year 1969 brought the AEC and the utilities face-to-face with public critics in efforts to dispel concern and fear that nuclear power would create local hazards and unduly affect the environment. Despite the outstanding safety record of the nuclear power industry, and an operational experience to date marked by the control of effluents generally well below prescribed safety standards, apprehension about the possibility of long-term effects of radioactive releases from nuclear powerplants contributed to growing public concern over atmospheric and terrestrial pollution in general. Numerous questions were raised by an uneasy public and from them came a general recognition by the AEC and the industry that more effort must be devoted to communications between the nuclear proponent and the man-on-the-street, with answers stated in simple, everyday language. From these confrontations, too, came a general recognition by the public that the AEC historically[1] has considered the local and general environmental effects associated with any nuclear activity—not on a "piecemeal" basis, but through hundreds of continuing projects and studies.

Regional Public Meetings

The year was marked by a sharp increase in the Commission's information activities in explaining the environmental considerations associated with the uses of nuclear energy. The first of these public meetings was held at the University of Vermont (Burlington) September

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[1] See pp. 186–188, 196, 201–204 of the second volume of the AEC's history, "Atomic Shield 1947–1952" which was published during 1969 (see footnote under "Historical Advisory Committee," p. 292 in Appendix 2, for availability of the book).

11. This meeting—speeches, and question-and-answer sessions—was sponsored by the Governor of Vermont and the senior U.S. Senator from the State, and was attended by about 1,400 persons. As a part of the day's program, about 900 high school students attended the science lecture program "This Atomic World," presented by Oak Ridge Associated Universities. A movie on nuclear power and the environment was also shown during the day and was seen by 750 persons.

In addition to the public meeting at Burlington, 15 seminars were given by the AEC at the University. More than 4,000 copies of the new

Selected for the 1969 Fermi Award "for his pioneering work in atomic energy," Dr. Walter H. Zinn, a vice president of Combustion Engineering, Inc., received the citation from AEC Chairman Seaborg. President Nixon approved the selection. The award, named in honor of the late Enrico Fermi, was presented in ceremonies in San Francisco on December 2, 1969. It consists of citation, gold medal, and $25,000. The presentation marked the twenty-seventh anniversary of the achievement of the first sustained nuclear chain reaction by Dr. Fermi and his team at Stagg Field, University of Chicago, in 1942. Dr. Zinn headed one of the groups charged with constructing the first successful atomic pile. In recognition, the citation reads: "For his pioneering work in atomic energy, including the world's first reactors and the fast breeder reactor, and for his distinguished record of leadership and contributions to the development of atomic reactors for research, production, propulsion, and electric power."

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AEC booklet "Nuclear Power and the Environment" (see Appendix 7 for availability) were distributed in Burlington and a new exhibit, bearing the same name as the booklet, was put into use. In all, direct contact was made by AEC personnel with an estimated 2,500 students and adults, exclusive of the radio and TV audience. Members of the AEC staff returned to Vermont on October 23 and 24 for public meetings at Brattleboro and Bennington.

A symposium designed for an in-depth discussion of the issues involved in the growth of nuclear power was sponsored October 10–11 by the University of Minnesota in Minneapolis. Members of the Commission and the Congressional Joint Committee on Atomic Energy, as well as representatives of other Federal agencies and scientific organizations were among the speakers.

The Commission also participated, in December, in a panel on "The Nuclear Controversy" at the annual meeting of the Atomic Industrial Forum in San Francisco, and in the "Northwest Conference on the Role of Nuclear Energy," at Portland, sponsored by the Governor of Oregon.

The Joint Committee on Atomic Energy conducted the first phase of hearings on the "Environmental Effects of Producing Electric Power" October 28–31 and November 4–7. The Commissioners were among the Government witnesses who testified. Early in 1970, the committee will hear from representatives of State governments, private industry, environmental groups, and the public at large.

Federal Powerplant Siting Committee

Commissioner James T. Ramey continued to represent the AEC on the "Interagency Power Plant Siting Committee" which was established by the White House's Office of Science and Technology (OST) in 1968. The committee is chaired by S. David Freeman, Director of the OST's Energy Policy Staff, and consists of representatives of the AEC, Federal Power Commission, Department of the Interior, National Air Pollution Control Administration (HEW), Rural Electrification Administration, and the Tennessee Valley Authority. The committee's initial report, "Considerations Affecting Steam Power Plant Site Selection," became available in 1969.[2] This report was intended to serve as a basis for discussion of whether additional surveys, research, or other action by industry or the Government is needed to protect the public interest. The committee continued to meet during

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.25.

1969 to attempt to identify what additional steps may be needed. It also formed a research subcommittee to determine in what areas additional research and development might be necessary to alleviate the powerplant siting problems now confronting the Nation. This subcommittee is chaired by a member of the AEC staff and has met with utilities, industry, and Government agencies to obtain information on the latest status of current efforts and what might be done in the future. The subcommittee is currently completing its report prior to presentation to the full committee.

Nuclear Non-Proliferation Treaty Ratification

In almost simultaneous signings by President Nixon in Washington, D.C., and Soviet President Nikolai V. Podgorny in Moscow on November 24, 1969, the United States and the Union of Soviet Socialist Republics took the final necessary step toward ratification of the Non-Proliferation Treaty (NPT). Under the terms of the agreement, which prohibits the manufacture or acquisition of nuclear weapons by nonnuclear-weapon countries, the treaty does not come into effect until the U.S., U.S.S.R., United Kingdom, and 40 nonnuclear-weapon nations deposit their instruments of ratification. The Non-Proliferation Treaty was initially signed by the U.S., the U.K., the U.S.S.R., and some 50 other countries on July 1, 1968. Currently, more than 90 countries have signed, and the U.K. and over 20 nonnuclear-weapon states have ratified the Non-Proliferation Treaty. The Treaty is expected to come into effect in early 1970.

Under Article I of the Non-Proliferation Treaty (NPT), nuclear-weapon-states party to the treaty are prohibited from transferring nuclear weapons or nuclear explosive devices, or control over them, to any recipient whatsoever, and from assisting, encouraging, or inducing any nonnuclear-weapon State to acquire them. Article II prohibits the manufacture or acquisition of nuclear weapons or other nuclear explosive devices by nonnuclear-weapon parties. Under Article III, nonnuclear-weapon parties undertake to accept safeguards, "with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices." The safeguards are to be applied to "all source or special fissionable material in all peaceful nuclear activities within the territory of such State . . . ." Articles IV and V should enhance progress in the peaceful uses of nuclear energy by parties to the NPT, and reflects, in large part, confidence that the treaty will inspire a kind of international cooperation in the peaceful uses of nuclear energy that will not contribute to the acquisition of nuclear weapons. The Non-Proliferation Treaty will facilitate the continuation and expansion of AEC's programs relating to international cooperation in the peaceful applications of nuclear energy, and will have an important impact on other international activities, particularly those of the IAEA.

Milestones Achieved in Nuclear Power Generation

On October 20, the AEC's dual-purpose "N" reactor near Richland, Wash., became the first nuclear powerplant to generate 10 billion kilowatt-hours (kw.-hrs.) of electricity. On November 13, the Yankee Plant at Rowe, Mass., also achieved this milestone, and at yearend two other nuclear plants were not far behind. These achievements provided an appropriate climax to the 1960s, a decade of notable progress in nuclear power operation.

This decade began with the then 60-Mwe. Shippingport Reactor in Pennsylvania as the only plant of commercial size producing electricity. But later, in 1960, both the Dresden reactor at Morris, Ill., and Yankee Plant began power generation. These two plants alternately led U.S. nuclear power producers throughout most of the decade. The Yankee Plant has been particularly steady in operation, achieving in its 9 full years of electricity generation, a plant capacity factor of about 75 percent. It was the first privately owned, single purpose plant in the world to attain the 10 billion kw.-hrs. level.

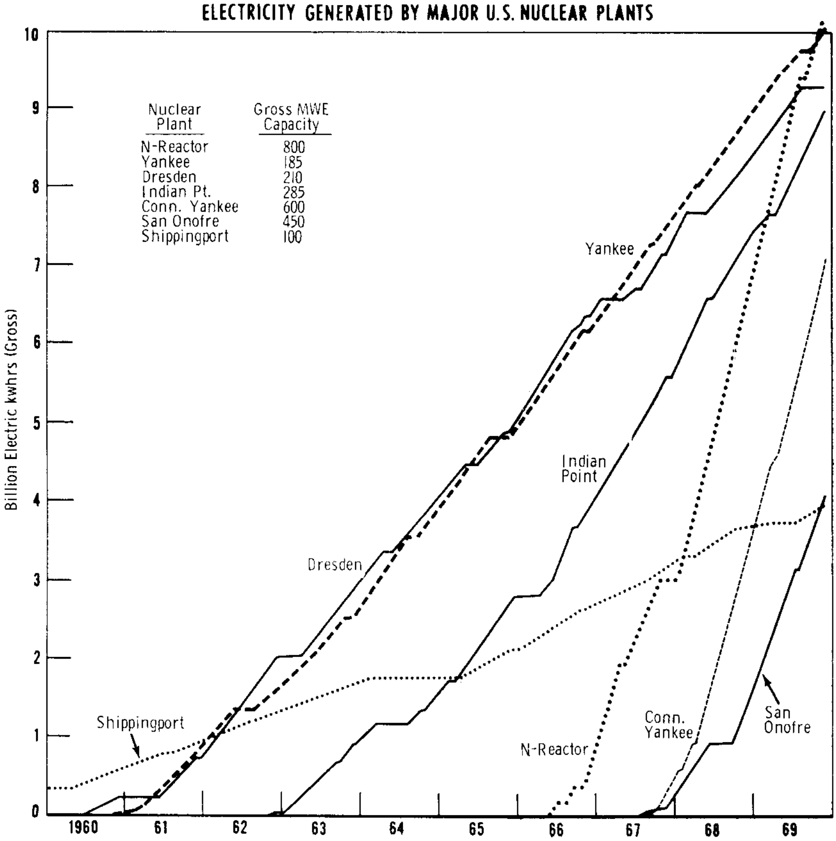
The Indian Point Station in Buchanan, N.Y., then rated at about 250 Mwe., went on the line in late 1962. It was primarily the operating experience of these first generation commercial plants—Dresden, Yankee, and Indian Point—and the projected operating costs for the Oyster Creek (N.J.) plant, that caused enterprising utilities to commit themselves to large nuclear generating stations. Reactor orders, placed at first with great caution and deliberation, came with spectacular frequency in the peak years of 1966–68, during which time commitments were made for some 65 large new plants.

In 1967, two new commercial plants, the San Onofre Station in Southern California, and the Connecticut Yankee Plant near Hartford, began power generation. They have provided valuable operating experience in the range of 400-600 Mwe., which is essentially double the size of the Dresden, Yankee, and Indian Point plants, and in turn about one-half the size of the next generation of plants now under construction.

One plant of the 1960's that does not fall logically into commercial categories of first or second generation reactors is the AEC's "N" reactor which, in 1964, began producing plutonium and other nuclear products for national defense. Then the Washington Public Power Supply System constructed an electrical generating station to utilize byproduct steam from the production reactor. This system came on the line in April 1966 and marked the beginning of dual purpose operation. The electric power produced has been distributed by Bonneville Power Administration to utilities and industrial customers throughout the Pacific Northwest.

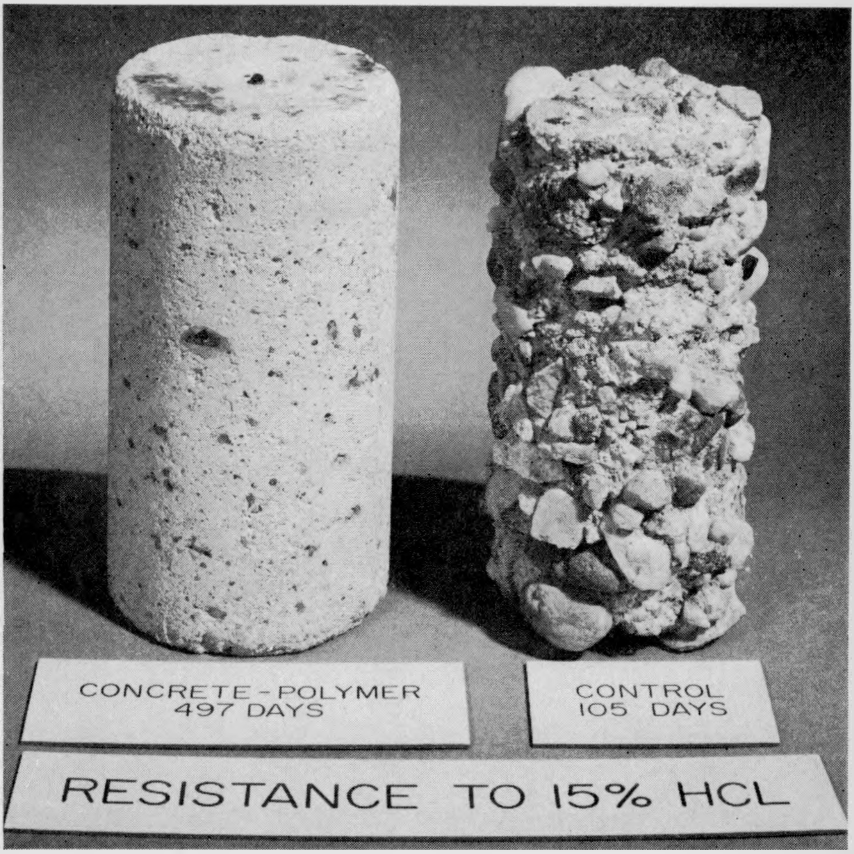
Because of its dual purpose operation, the plant capacity factor of the "N" reactor is not comparable with commercial plants. Nevertheless, because of its total capacity of about 800 Mwe. and the recent reliance upon this plant to avert a power shortage in the northwest, the Hanford reactor achieved the milestone of 10 billion kw.-hour in only 3½ years of electric power generation. Shippingport, in December 1961, was the first nuclear plant to reach the 1 billion kw.-hr. figure. The chart shows the power generation experience of the seven major U.S. nuclear plants during the 1960's.

ELECTRICITY GENERATED BY MAJOR U.S. NUCLEAR PLANTS



Magazine Honors Five AEC Developments

Five AEC developments were chosen as among the top 100 most significant technical products or developments of the year 1969. The awards are made annually by Industrial Research magazine. Included were:



Concrete-Polymer was Cited During 1969 as one of the 100 most significant new U.S. technical product developments. Concrete-polymer was developed at the AEC's Brookhaven National Laboratory in a joint research program with the U.S. Department of Interior's Bureau of Reclamation and Office of Saline Water. The 100 products were selected on the basis of their technical importance, uniqueness, and usefulness, by a panel of 30 scientists, engineers, and research administrators, all members of the editorial advisory board of Industrial Research magazine which sponsors the annual awards. The super material results from impregnating concrete with a plastic monomer and then exposing it to intense gamma radiation. Photo compares the concrete-polymer (*left*) with ordinary concrete (*right*) after the two samples had been soaked in a hydrochloric acid (HCl) bath.

- Concrete-polymer—a radiation processed, super-strength building material made of concrete and plastic, developed at Brookhaven National Laboratory. (See photos in this Introduction and in Chapter 10—Isotopic Radiation Applications.)
- An acoustic weld monitor which accurately detects flaws in welds as they are being made, developed at Pacific Northwest Laboratory. (See photo in this Introduction.)
- The world's largest superconducting magnet which is a part of the new 12-foot bubble chamber at Argonne; first particle tracks were observed with the aid of the chamber in October 1969. (See drawing in this Introduction and photos on p. 130 of supplemental "Fundamental Nuclear Energy Research—1969" report.)
- A Braille machine that can take symbols from ordinary magnetic tape and play them back as patterns of raised dots on an endless plastic belt, developed at Argonne National Laboratory under a grant from the U.S. Office of Education to the University of Chicago. (See photos in this Introduction.)
- The GeMSAEC, a device for increasing the number and precision of tests performed on body fluids (blood and urine) in clinical laboratories, developed at Oak Ridge National Laboratory in cooperation with the National Institute of General Medical Sciences. (The acronym name of the device was composed from the names of the two sponsoring organizations.) (See photo on p. 1 of supplemental "Fundamental Nuclear Energy Research—1969" report.)

As a medical "spin-off" of basic nuclear research on the metabolism of trace metals in the human body, victims of Parkinson's disease have been aided by an experimental therapy developed at Brookhaven National Laboratory. The development of L-Dopa was lauded in an editorial in the New England Journal of Medicine (see Chapter 15—Biomedical and Physical Research).

CONTENTS SUMMARY

The next 21 pages of this "Annual Report to Congress for 1969" [3] summarize the contents on a chapter by chapter basis. Advancements in AEC-sponsored basic research and exploratory development are included in the supplemental report, "Fundamental Nuclear Energy Research—1969." [4]

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[3] This "Annual Report to Congress for 1969" is available to the public under an alternate title, "Major Activities in the Atomic Energy Programs—January–December 1969," from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.75.

[4] "Fundamental Nuclear Energy Research—1969" is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3.75.

Source and Special Nuclear Materials

- The high rate of exploration activity in the last several years has resulted in a substantial increase in uranium ore reserves during 1969, the largest in any single year since 1957.
- The AEC reduced its uranium concentration purchase commitments for 1969 and 1970 by about 4,000 tons of U_3O_8. The purchases in 1969 were 6,200 tons, leaving 3,400 tons remaining to be delivered in calendar year 1970. No further government purchases are planned beyond this date.
- Toll enriching services in AEC gaseous diffusion plants became available beginning January 1, 1969, to domestic and foreign customers. To encourage sales of normal uranium by domestic suppliers and to increase near-term revenues to the AEC, conversion of leased-uranium to privately owned material through *in situ* toll enriching was authorized to begin in April 1969 instead of in January 1971 as had been initially planned.
- On November 10, 1969, the President announced his decision that the uranium enrichment activities are to be conducted in a manner more closely approaching a commercial enterprise by a separate organizational entity within the AEC. The new entity, which will be an AEC directorate, will maintain separate accounting records and will publish periodic financial reports similar to those of commercial enterprises.
- A vigorous program to produce gram quantities of californium-252 is in progress at Savannah River for a wide variety of uses in medicine, industry, research, and education.
- The Waste Calciner Facility (WCF) at the National Reactor Testing Station, Idaho, completed a processing campaign that extended from August 1968 to June 1969. Nearly 330,000 gallons of liquid waste were reduced to 35,200 gallons (or 4,700 cubic feet) of granular dry waste for storage in underground vaults. Nearly 2 million gallons of highly radioactive liquid wastes have been converted into slightly less than 200,000 gallons of noncorrosive solids since the WCF started operations in December 1963.
- In pricing actions concerning certain radioisotopes, the AEC increased its price for polonium-210, and canceled price increases scheduled to go into effect for cesium-137. At midyear, the AEC offered to loan high specific activity cobalt-60 free to organizations willing to undertake research and development with their own funds.

Safeguards and Materials Management

● Substantial progress was made during 1969 in the development of transportable equipment for the nondestructive safeguards and materials management measurements of assemblies and packages containing special nuclear materials. A transportable trailer equipped for analysis by neutron activation-fission detection techniques was demonstrated at Los Alamos Scientific Laboratory. A trailer equipped to use photon activation techniques was nearing completion by Gulf General Atomic.

● A safeguards program research and development symposium at Los Alamos, N. Mex., and La Jolla, Calif., attracted government, industry, and foreign representatives concerned with safeguarding nuclear materials.

The Nuclear Defense Effort

● The AEC continued a comprehensive underground nuclear test program at the Nevada Test Site and supplemental areas as 27 defense-related underground tests were publicly announced in 1969. An underground nuclear calibration test was successfully conducted at Amchitka Island, Alaska, on October 2.

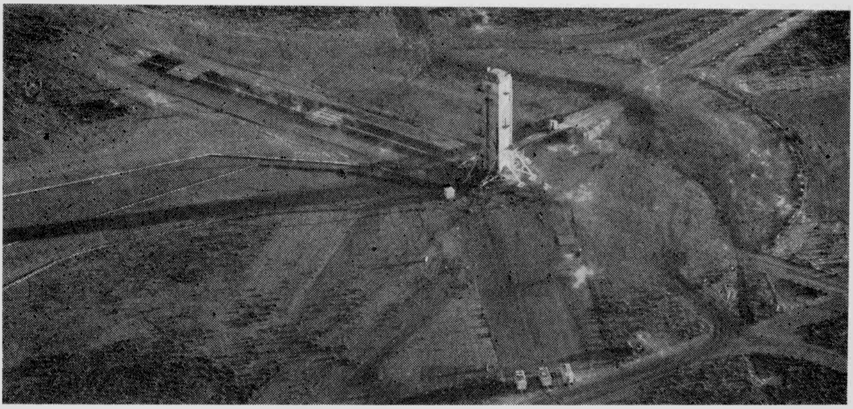
● A major fire at the AEC's Rocky Flats plant in Colorado on May 11 reduced the plant's capacity to produce plutonium components for a time, but did not endanger the public; including cost of decontamination work, the damage estimate is about $45 million.

Naval Propulsion Reactors

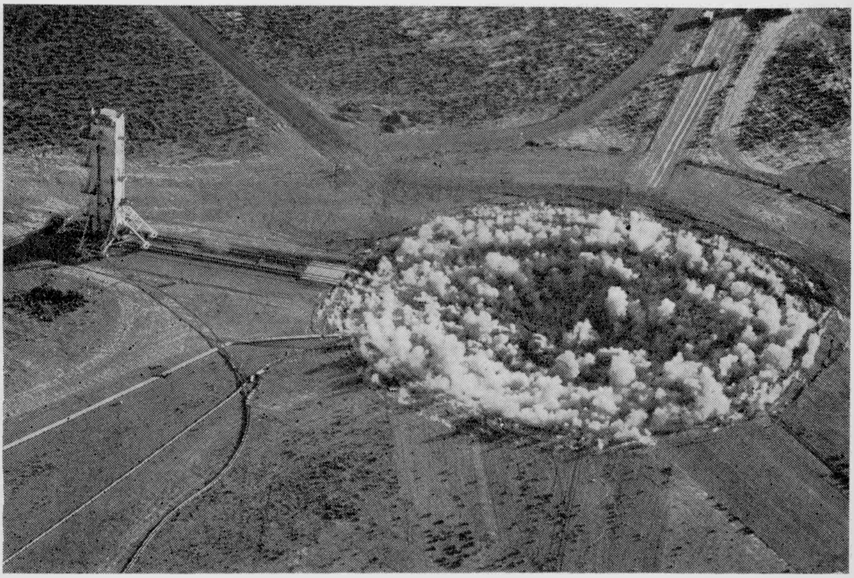
● The *Enterprise* returned from her fourth Vietnam combat deployment and, at year's end, was being refueled for only the second time since 1961.

● The world's first nuclear-powered deep submergence research vehicle, the NR–1, successfully completed initial sea trials. Manned by a crew of five and two scientists, it has a capability for exploring essentially all of the U.S. Continental Shelf, an area rich in mineral and food resources.

● Construction proceeded on two new guided-missile nuclear frigates. Throughout 1969, the AEC continued to emphasize research and development work on advanced naval reactor cores of greater reliability, higher power, and longer life.

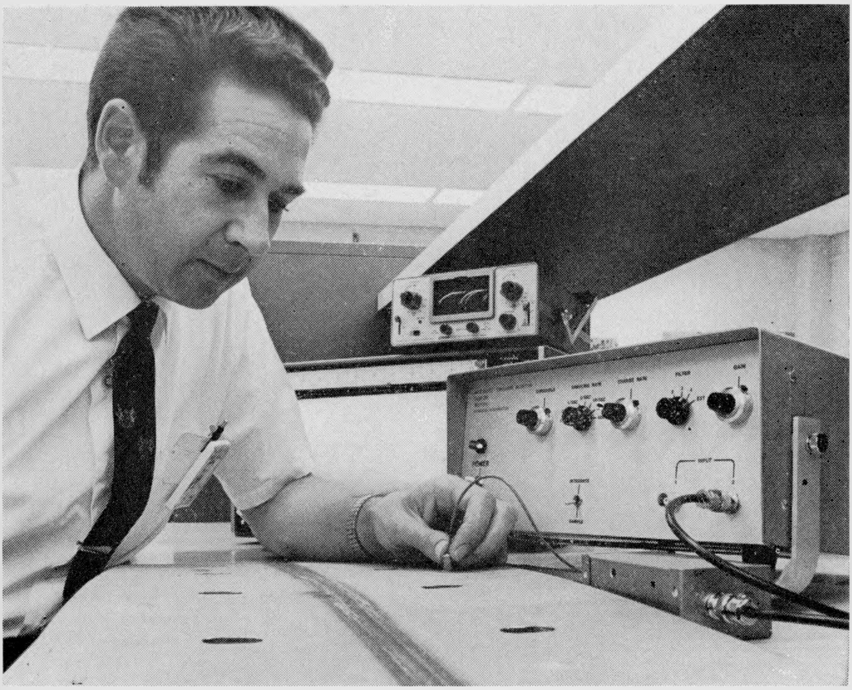


Little More Than a Minute after a mid-1969 nuclear detonation deep under the Nevada Test Site surface, wisps of dust, created by the shockwave, began to rise (photo *above*) from ground zero. Above the detonation point stood a tower on wheels, as tall as a 10-story building and loaded with Los Alamos Scientific Laboratory (LASL) scientific experimental apparatus. Then cables began pulling the 200-ton tower along the tracks to the left. And, 20 minutes later, when the ground collapsed into the cavity caused by the detonation, the valuable 100-foot tower was safe, about 225 feet from the 175-foot crater's edge as shown *below*. This was the first time a tower of this size had ever been retrieved intact in the history of the AEC's underground nuclear testing program. In the past, salvaging equipment from a collapsed tower took considerable time and effort. The techniques devised by the LASL crew to save their tower is expected to enhance future basic research experiments conducted as "add-ons" to the nuclear weapons testing. The towers and the scientific equipment will no longer have to be considered as expendable—a considerable dollars saving as well as time and effort.



Reactor Development and Technology

- A total of 97 nuclear central station powerplants were in operation, under construction, or had been contracted for at the end of 1969 (see Table 1 at end of this Introduction).
- Emphasis continued on breeder reactor development as design studies were continued on a 1,000-Mwe. plant. Contractors for the liquid metal fast breeder reactors (LMFBR) and the AEC entered into the project definition phase for industry-utility construction of 300- to 500-Mwe. LMFBR demonstration plants.
- Work continued on the development of satisfactory fuels and materials for LMFBR units and to related irradiation and test facilities.



A Revolutionary Monitoring Device, which instantaneously detects flaws in welds, has been developed at Pacific Northwest Laboratory as part of the AEC's nondestructive testing research and development program. The device, by recording high-frequency sound waves (acoustic emissions), can detect flaws (cracks, inclusions, etc.) which may form in a material during and immediately following a welding operation. The monitor, one of the five AEC developments honored by Industrial Research magazine in 1969 as one of the 100 most important technical developments, is already being manufactured commercially by NORTEC, a Richland, Wash.-based subsidiary of Battelle Memorial Institute's Scientific Advances, Inc.

● Major new LMFBR research and development facilities, including the Zero Power Plutonium Reactor and the Southwest Experimental Fast Oxide Reactor, were placed in operation.

● The AEC has issued additional engineering standards, including quality assurance program standards, to provide increased assurance that AEC reactor development facilities and equipment will meet their performance requirements with safety and reliability.

● The AEC is carrying out an extensive safety and environmental effects research and development effort, and obtaining information vital to the siting and operation of nuclear facilities.

Licensing and Regulating the Atom

● Operating licenses were issued for four large nuclear powerplants, more than doubling the Nation's installed nuclear power capacity to 4,291 Mwe.

● At yearend, 47 nuclear plants were under construction and applications for 24 units were pending with AEC. Scheduling problems in producing reactor vessels or components resulted in industry's turning to foreign fabricators, thus requiring extension of AEC regulatory inspections to manufacturing plants in several countries.

● Jurisdictional problems arose with certain of the States regarding limits on releases of radioactivity to the environment from nuclear facilities. A late fall public hearing before the Congressional Joint Committee on Atomic Energy capped the year's preoccupation with the effects of power production on the environment.

● The Commission established an Atomic Safety and Licensing Appeal Board and delegated it the authority to function in: (*a*) Those proceedings on applications for licenses or authorizations in which the Commission has a direct financial interest, and (*b*) such other licensing proceedings as the Commission may specify.

● AEC licensees continued to compile a good radiation safety record. With 118 power, test, and research reactors licensed by the AEC since 1954, these facilities had, by yearend, compiled about 840 reactor years of operation without a radiation fatality or serious radiation exposure to operating personnel or members of the public.

● The AEC completed 5 initial licensing proceedings in 1969 and issued provisional construction permits for 7 new nuclear power units to be located in Georgia, Maryland, Michigan, New York, and Pennsylvania. Utilities filed construction permit applications for 14 nuclear power units during the year.

● For the third successive year, refunds were paid by the MAELU and NELIA insurance pools to holders of nuclear liability commercial insurance policies dating from 1959, as a result of the excellent safety record of the nuclear industry. The industry's retrospective credit rating plan is based on loss experience over a 10-year period.

- North Dakota, South Carolina, and Georgia became the 20th, 21st, and 22d States, respectively, to enter into regulatory agreements with the AEC under section 274 of the Atomic Energy Act of 1954 which recognizes the interests of States in regulating the peaceful uses of atomic energy.

Operational and Public Safety

- Five fatalities occurred in 1969 as the result of construction activities; none involved nuclear cause.
- An AEC employee received a significant radiation exposure while working with an X-ray diffraction machine. The employee's exposure from the narrow beam of soft X-rays to fingers of the left hand was estimated to be 2,000 rem. Four lesser radiation exposures occurred, one whole-body and three internal.

Nuclear Rocket Propulsion

- The tests on the NERVA ground-experimental engine (XE) were completed at the Nuclear Rocket Development Station in Nevada. This test program was the last activity to be completed in the NERVA technology phase of the joint AEC/NASA nuclear rocket program.

Specialized Nuclear Power Units

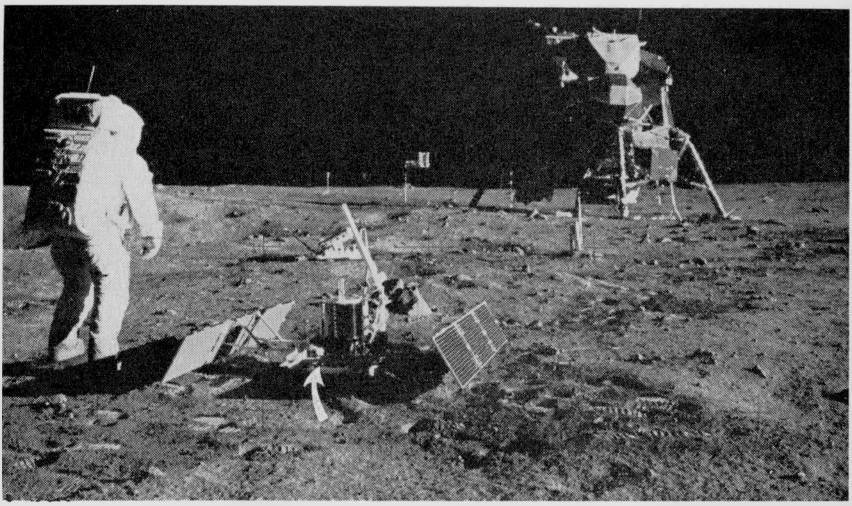
- In June 1969, a SNAP–3A radioisotope generator—the first orbited—entered its ninth year of operation in space, having operated more than 3 years beyond its 5-year design life expectancy.
- Since their launch in April 1969 aboard the Nimbus III weather satellite, the two 25-watt SNAP–19 radioisotope generators have been supplying power as designed.
- Two plutonium-238 fueled isotopic heaters, each producing 15 thermal watts, were left on the moon July 19, 1969, by the Apollo 11 astronauts to warm seismic instruments during the long lunar nights when temperatures drop to −250° F.
- Placed on the moon on November 19, 1969, by the Apollo 12 astronauts as part of the Apollo Lunar Surface Experiments Package, a SNAP–27, 63-watt radioisotope generator has been supplying full power to that automated station since its activation in November.
- The AEC is evaluating generators of the modified SNAP–19 type as the power sources of the 1972–73 Pioneer Jupiter probes and the 1975 Viking Mars Lander packages.

MAN EXPLORES THE MOON

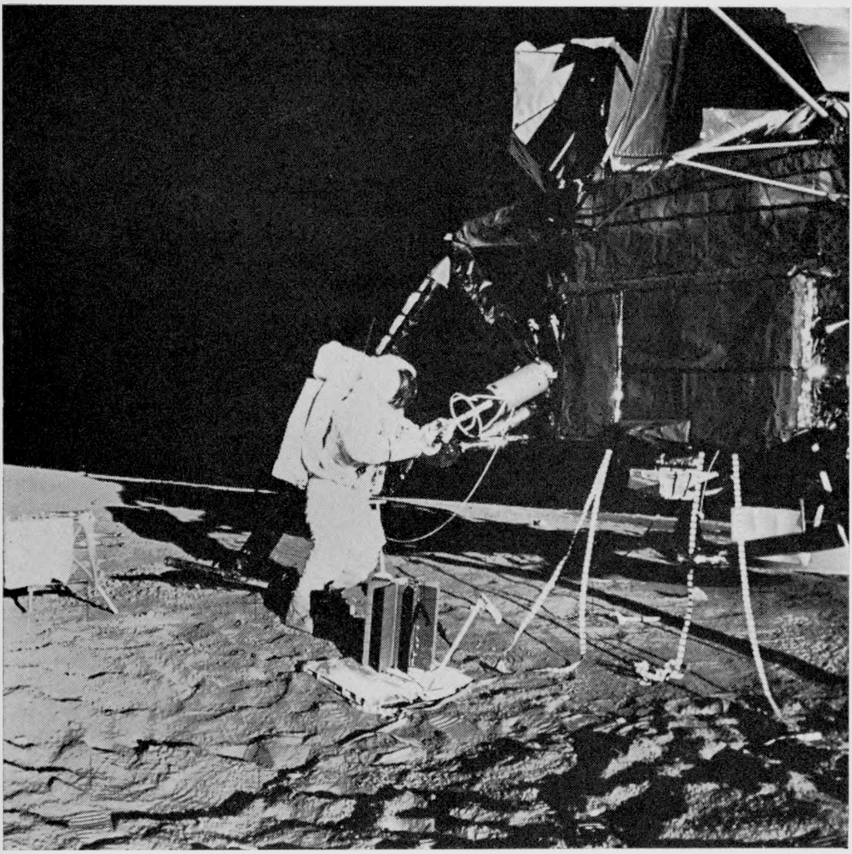
For centuries, man has gazed at the moon—240,000 miles distant from the earth—and pondered how it was formed, its elemental composition, its physical features, and whether any form of "life" existed there. In 1865, Jules Verne—the French science fiction writer who foresaw atomic energy—fictionally landed Earthmen on the lunar surface in "*From the Earth to the Moon*;" they found a form of "life."

In 1969, man set foot on the moon for the first time and returned to earth bringing samples of lunar dust and rocks—man's physical exploration of the moon had begun—and there was no indication of "life."

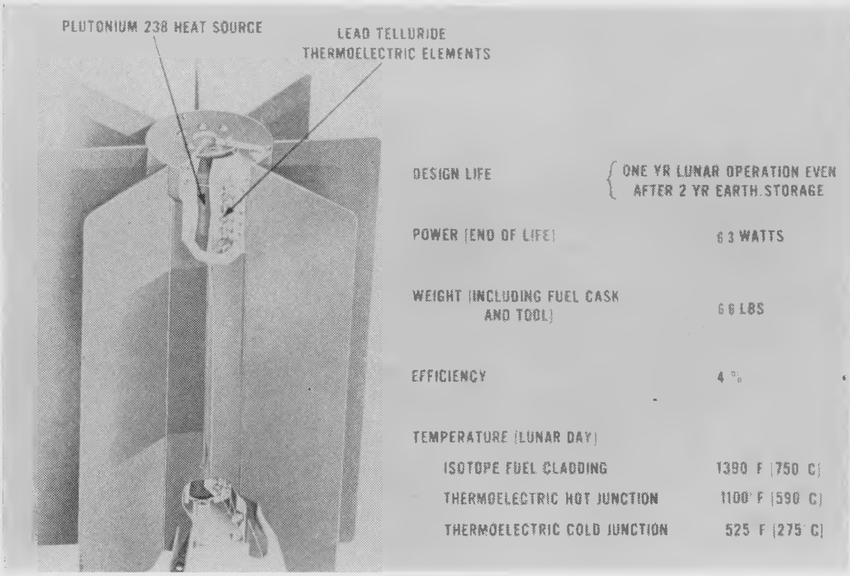
The National Aeronautics and Space Administration's (NASA) successful landings and return of the Apollo 11 and 12 astronauts involved many organizations and people. On this and the next seven pages, in pictures and words, the part the AEC and its contractors are playing in the moon exploration program is summarized.



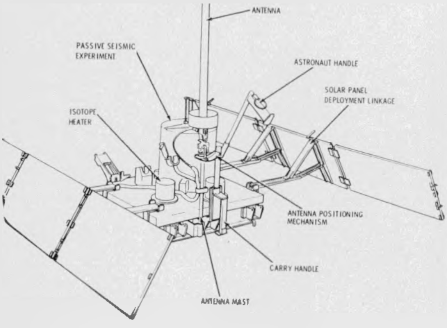
The First Nuclear Energy Devices on the Moon were the two small (3 inches high), plutonium-238 fueled heaters left by the Apollo 11 crew—Neil Armstrong and Edwin (Buzz) Aldrin—to keep the passive seismic experiment package "warm" during the long lunar nights. While the Apollo program is a National Aeronautics and Space Administration (NASA) project, the AEC, its laboratories, and contractors are participating in a variety of ways. Photo *above* shows the seismic experiment at "Tranquility Base"; the reflection from one of the heaters is indicated by the *arrow*. Each heater, designed and fabricated at the AEC's Mound Laboratory, produced 15 watts of heat from the decaying plutonium, enough to keep the temperature near the seismic instruments at −65° F. during the long lunar nights (equal to 14 earth days) when the temperature drops to about −250° F. (see diagram on p. 18).

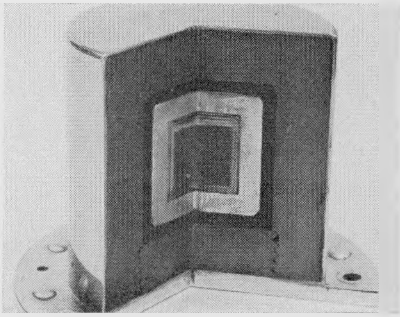


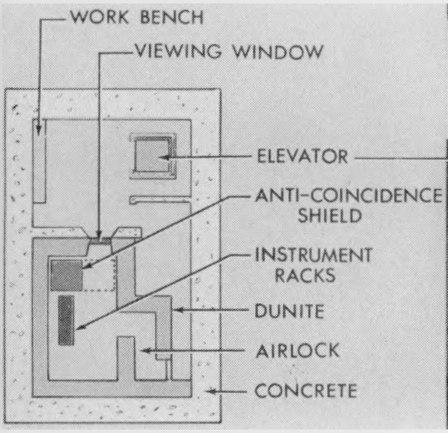
Nuclear Electric Power Arrived on the Moon for the first time on November 19, 1969, when the Apollo 12 astronauts—Charles (Pete) Conrad and Gordon Bean—deployed the AEC's SNAP–27 on the lunar surface to provide the power for the six experiments and the transmission data of the ALSEP (Apollo Lunar Surface Experiments Package). Photo shows Bean removing the plutonium-238 heat source from the container which carried it on the outside of the landing module; the SNAP–27 thermoelectric generator is near his feet. When the plutonium-238 heat source was placed in the generator and the shorting bar was removed, the SNAP–27 began producing 73 watts of electrical power. The SNAP–27 generator and its supporting hardware were designed, fabricated and tested for the AEC by General Electric's Missile and Space Division (Valley Forge, Pa.); the AEC's Sandia Laboratories provided technical direction and assisted the AEC in safety evaluation for the SNAP–27; and the plutonium power source was encapsulated by the AEC's Mound Laboratory. The ALSEP was put together for NASA by Bendix-Aerospace Systems Division (Ann Arbor, Mich.) and consisted of: A magnetometer to help reconstruct the geological evolution of moon; a solar wind spectrometer to determine the composition of the sun; a lunar atmosphere detector to learn more about the early history of the moon; and a lunar ionosphere detector to measure positive ions immediately above the lunar surface.

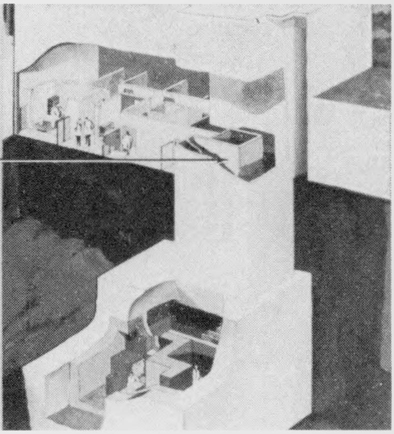


About the Same Size as an office waste basket and having no moving parts, the SNAP–27 is the sole source of electric power for the scientific instruments of the Apollo Surface Experiments Package deployed by the Apollo 12 astronauts on the moon November 19. The power is generated by converting the radioactive decay heat from the plutonium-238 heat sources into electricity through a thermoelectric action—if two dissimilar metallic materials are joined together at both ends in an electrical circuit, an electric current will flow around the loop if one of the junctions is kept hotter than the other. For the SNAP–27, the hot junction temperature is 1,100° F., while the cold junction temperature is 525° F. The Apollo 13, 14, and 15 moon landings, and possibly others, are scheduled to include deployments of SNAP–27 power units. Drawing, *below left,* shows the major components of the seismic package and the placement of the two 3-pound heaters left on the moon by the Apollo 11 crew. Cutaway view of a lunar heater unit is shown below *right.* Each heater has 37.6 grams of plutonium-238 dioxide microspheres (center square) surrounded by a graphite ablative heat shield (dark outer area). The heaters kept the seismic instruments warm enough for operation through the first lunar night and scientists on earth picked up signals indicating about 100 moon vibrations before electrical malfunctions reduced the information being transmitted to earth.

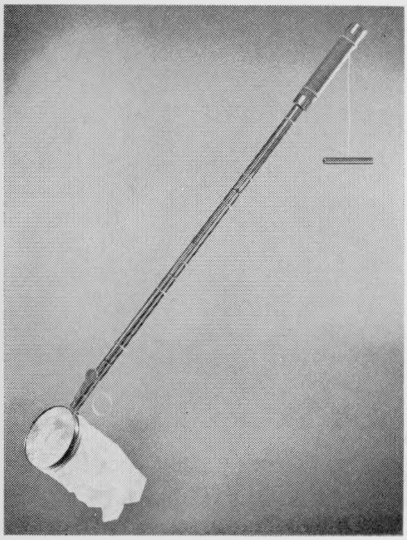








The Oak Ridge Y–12 Plant, under a NASA agreement, designed, built, tested, and supervised the initial operation of a special environmental control system (shown *above*) for an underground, low-level radiation laboratory which was used for radiation monitoring tests on geological samples returned from the moon by Apollo astronauts. The lunar contingency sampler, shown at *left below*, with which man scooped up his first sample of moon dust and rocks, was designed and built at Oak Ridge National Laboratory. Identical models were used on both Apollo 11 and 12. The airtight boxes in which the astronauts returned moon rocks and dust to earth were developed at the Y–12 Plant. In photo *right below*, a Y–12 technician uses a fluorescent light and a needle-sized vacuum cleaner to remove lint particles from an Apollo moonbox. The cleaning operation was one of a series of preflight decontamination steps to assure that there will be no earth dirt in the box to contaminate soil samples obtained from the moon. The Y–12 Plant and Oak Ridge National Laboratory are operated by Union Carbide Corp., Nuclear Division, for the AEC.



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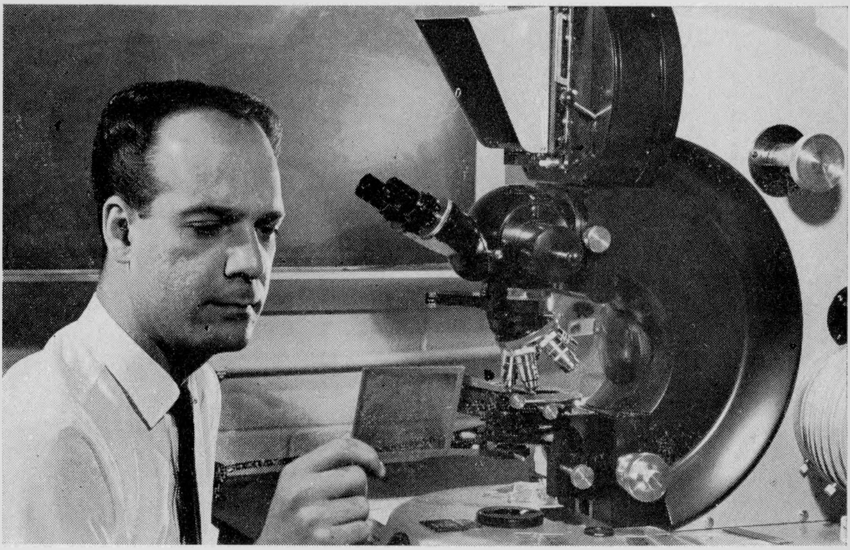
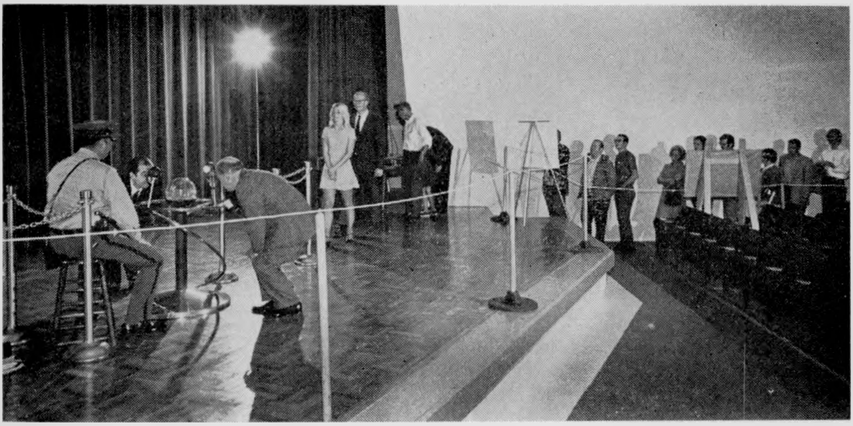
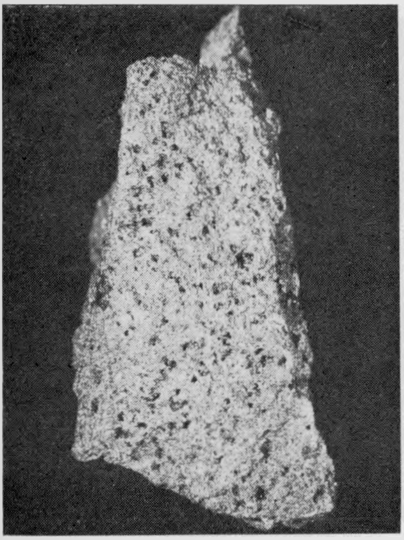
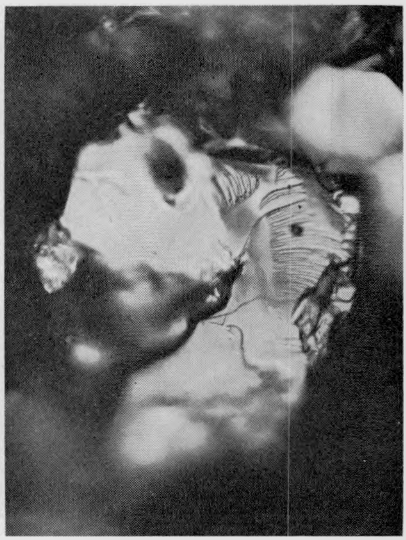


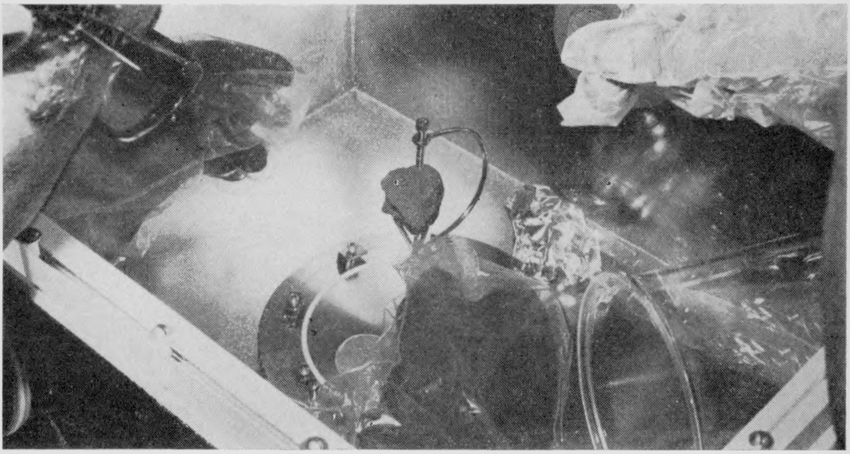
Lunar Samples Brought Back to Earth by the Apollo 11 and 12 astronauts contained no form of life. The tests (shown *above*) to determine if there were any life forms in the material were performed for NASA by Dr. Michael G. Hanna, Jr., Oak Ridge National Laboratory (ORNL) experimental pathologist. A colony of germ-free mice developed at ORNL was used to determine moon dust effects on earth life. A variety of items relating directly to manned space travel (Apollo 7 through 11) have undergone close scrutiny at the AEC's Pacific Northwest Laboratory (PNL) under a Battelle-Northwest contract with NASA. A portion of a reflector shield from Apollo 10, shown *below* was checked by highly sensitive PNL counting equipment to determine the amount of radiation encountered in space. Studies involving portions of astronaut's space suits and astronaut's body wastes also were among those conducted for NASA. During November, in the Richland, Wash., Federal Building lobby, more than 21,500 persons saw a rock and a container of dust from the moon's surface displayed by PNL before Battelle-Northwest began its NASA-assigned analysis of the lunar samples.



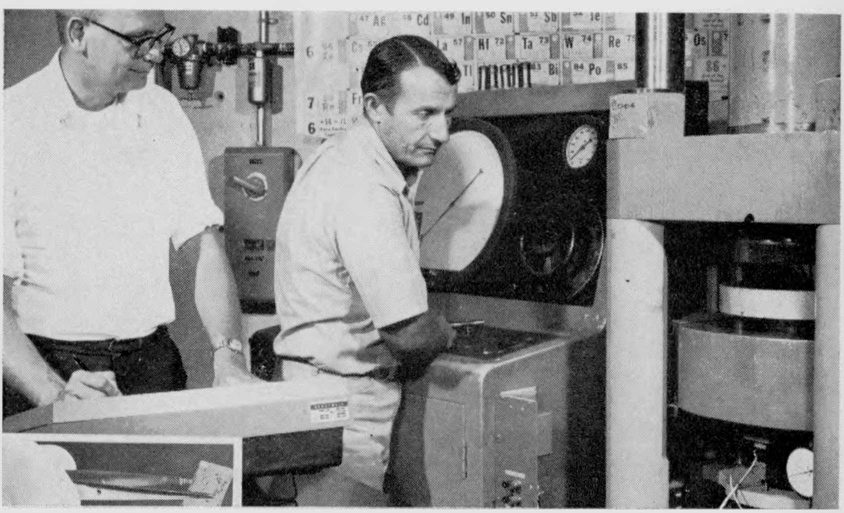
About 47 pounds of Lunar Rocks were returned to earth by the Apollo 11 crew and NASA apportioned the material out for scientific study and public viewing. Photo *above* shows part of the crowd of several thousand who viewed the 12-gram piece of the moon that was sent to Brookhaven National Laboratory for evaluation under a NASA agreement. The research at Brookhaven involves heating the sample to drive off the gases it contains, and then analyzing the gases for their radioactivity. The principal gases being analyzed are argon, krypton, and xenon. By comparing the analysis of the radioactive (nonstable) gas, which has a known half-life, with the stable isotopes of the same gas, much new information can be learned about the moon material, its formation, composition, and history, and thus adding to man's knowledge about outer space and our universe. Initial study showed the 1¼-inch sample (*left below*) contained feldspar, pyroxene, and ilmenite and is a fine-grained basalt type rock. At *right below* is a greatly enlarged photomicrograph of the detail of the lunar sample showing an area that sparkles.

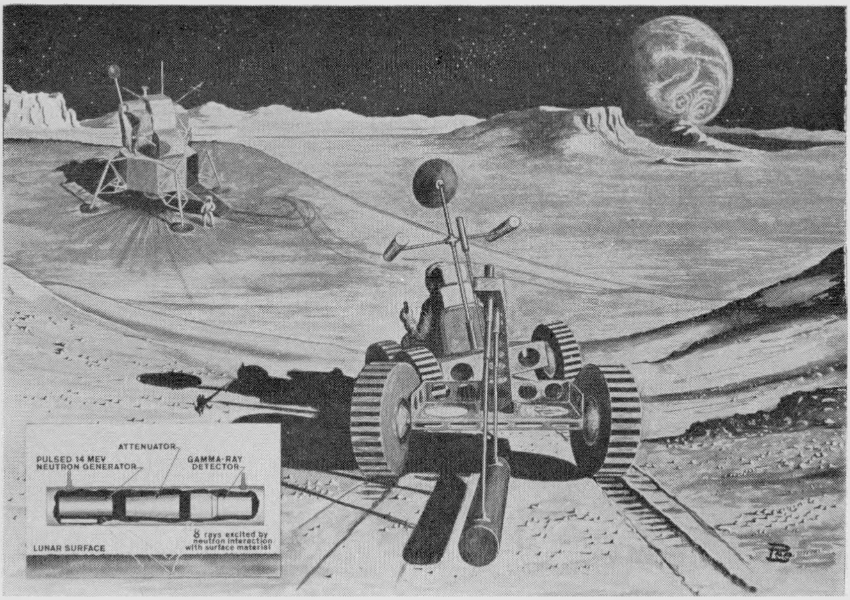






Analysis of the Moon Samples for NASA has shown that the lunar surface consists largely of silicon-rich basalt similar to the earth's rocks. The moon samples have enough radioactive minerals—uranium, thorium, potassium—to indicate there was sufficient radioactivity in the early moon's interior to produce the heat necessary to melt rock and cause volcanism. Photo *above* shows a sample in a glovebox at the AEC's Lawrence Radiation Laboratory (LRL) in Berkeley. Spectroscopic analysis of a tiny 50-milligram fragment at Berkeley indicated 49 percent silica, 12 percent iron, 12 percent calcium, 10 percent alumina, 8 percent magnesium, 7 percent titanium oxide, and traces of nickel similar to those in earthly basalt. Photo *below* shows the high compression press at LRL-Livermore being prepared for use on the lunar rock samples to make pressure-volume tests on a lunar sample (see *inset* at the bottom). Pressures of over 40,000 times normal earth atmosphere can be achieved with this equipment. These experiments are fundamental to understanding the physical nature of the rock, and will serve as a basis in calculating the impacts of meteors on lunar material.





A Mobile Materials Analyzer is being developed by the AEC under a NASA agreement—for future surface exploration of the moon—to measure the relative concentrations of the major lunar elements, including the possible presence of hydrogen (water). The scanner probe (containing a neutron generator and a gamma-ray detector) is shown in the artist's conception *above* suspended from the rear of a roving vehicle driven on the moon's surface by an astronaut. The probe also could be landed remotely from a soft-landing unmanned spacecraft. An electronic computer control system would be located either on the roving vehicle or in the unmanned spacecraft and the data transmitted to earth by telemetry for analysis. A cutaway drawing of the scanner probe arrangement is shown in the *inset*. A major advantage of this proposed experiment over other techniques is its ability to analyze the moon's surface to depths of 2 to 3 feet with redundancy, since several different measurements would be made simultaneously. The nuclear analytical techniques involved were originally developed for AEC programs as parts of the reactor and isotopes technology programs. Scientists from Idaho Nuclear Corp., Mobile Oil's Research Laboratories, Illinois Institute of Technology, Lawrence Radiation Laboratory, and Sandia Corp., are cooperating in development of the moon scanner. The design responsibility assigned to Idaho Nuclear at the National Reactor Testing Station in Idaho involves development of the electronic instrumentation required for acquiring the data and controlling the experiment. This includes developing a prototype of the scanner system and technical specifications for the final flight hardware in cooperation with the other members of the research team.

Isotopic Radiation Applications

- A technique has been developed for tracing stream pollution in pulp and paper industry regions using wood fiber "tagged" with an iridium salt. Waste water downstream from the plant is sampled and subjected to activation analysis for iridium. Stream pollution can be thus determined and plant efficiency improved simultaneously.
- A joint AEC-Federal Water Pollution Control Administration study completed in 1969 showed it was not immediately practical to use nuclear radiation for waste water treatment. The study is continuing in areas showing some potential use.

The Plowshare Program

- A 40-kiloton nuclear explosive (Project Rulison) was detonated 8,430 feet below surface in Garfield County, Colo., to determine changes in gas production and recovery rates and to gather additional information on use of nuclear explosives for gas stimulation.
- A simplified field operations procedure has been developed for use in Plowshare projects. It reduces the number of personnel, cost, and time required for experiments, and ultimately for commercial Plowshare applications once the AEC's participation in them is authorized by law.

International Cooperation Activities

- For the ninth year AEC Chairman Seaborg headed the U.S. Delegation to the General Conference of the International Atomic Energy Agency in Vienna, Austria. In 1969, he also visited Romania, Czechoslovakia, the U.S.S.R., Hungary, Portugal, Sweden, and Switzerland, in furtherance of the U.S. policy objective of advancing the peaceful uses of atomic energy.
- Seventeen toll enrichment contracts were signed with foreign users. These contracts have an estimated value of approximately $400 million.

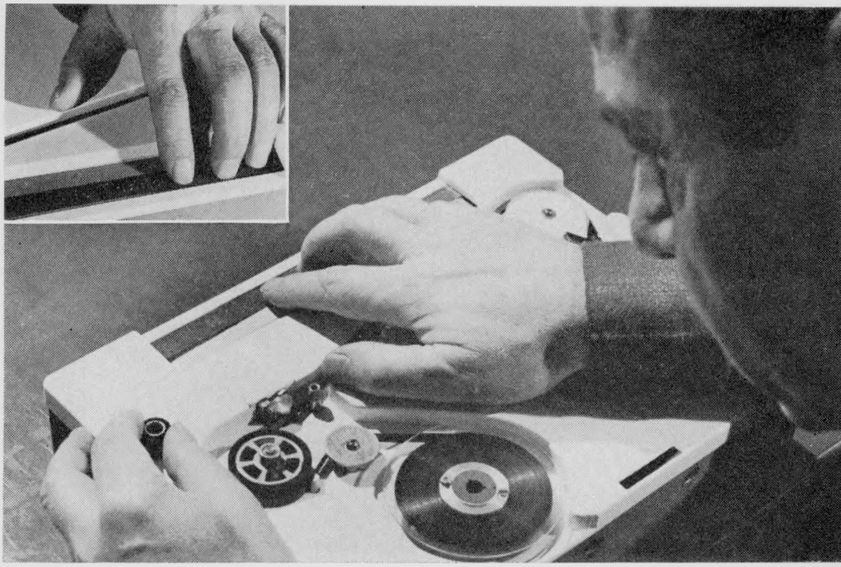
Informational and Related Activities

- Thirteen AEC films were entered in 28 different international cinematographic events. Two received special honors: "Brookhaven Spectrum," the "Particular Merit Award" from the Sixth International Labor and Industrial Film Triennial, Antwerp, Belgium; a "Golden Eagle Award" was presented to "Combustion Techniques in Liquid Scintillation Counting" by CINE, Washington, D.C.

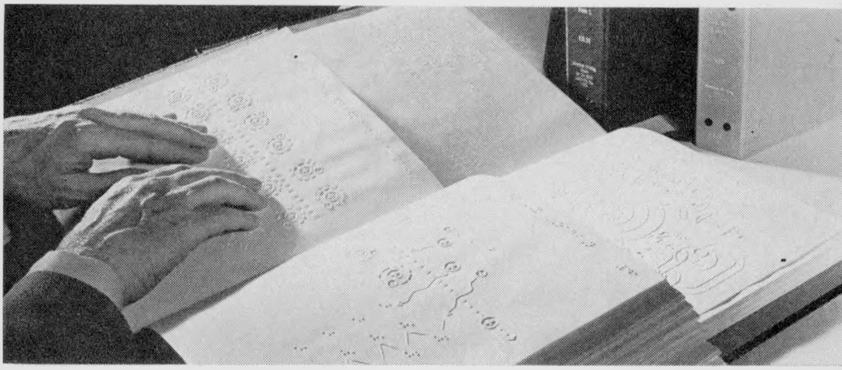
- The first of a new series of radio programs—"Seaborg on Science"—a record containing 10 3½-minute programs, was sent to 1,200 commercial and educational broadcasting stations in the United States and Canada.
- Progress continued toward the inauguration of an International Nuclear Information System and in the development and strengthening of advanced methods for disseminating scientific and technical information to diverse domestic audiences.
- Continued expansion of the successful "This Atomic World" lecture-demonstration program resulted in 23 units being in service at the start of the 1969–70 school year; 17 of the units operate under cooperative agreements with State organizations.
- During 1969, "Atoms-in-Action" Nuclear Science Demonstration Centers were presented in Manila, Bucharest, and Sao Paulo. The presentation in Romania was the first in Eastern Europe since Yugoslavia was visited in 1963.
- Declassification review has resulted in the reduction of numbers of classified documents held at several storage facilities, thereby reducing the cost involved in the surveillance of these documents.
- A total of 267 United States and 302 foreign patents were issued to the AEC during the year. The AEC issued six public announcements of new U.S. and foreign patents available for licensing. Some 106 nonexclusive licenses were granted on U.S. patents and patent applications.

Nuclear Education and Training

- AEC assistance to colleges and universities for education in the nuclear sciences and engineering diminished slightly in 1969 because of budgetary limitations. Momentum was maintained in most of the educational programs although some, notably equipment grants and faculty training institutes, declined substantially.
- A new reactor sharing program, designed to ease the growing need for additional campus reactors, was instituted during 1969.
- A significant effort to expand cooperative research and education programs with predominantly Negro institutions was initiated by a "Workshop for Faculty of Emerging Engineering Institutions" held at Oak Ridge Associated Universities during the month of August.



Symbols in the Braille Alphabet are reproduced as patterns of raised dots on an endless plastic belt in a Braille machine developed at the AEC's Argonne National Laboratory under a grant from the U.S. Office of Education to the University of Chicago. Photo *above* shows a prototype model of the machine; *inset* is a close view of the tape. The symbols are erased and new symbols are reproduced each time the belt passes through the machine. This new Braille device should vastly increase the volume and reduce the cost of literature available in Braille. The machine was one of the 5 AEC developments listed among the top 100 technical advancements during 1969 by Industrial Research magazine. Blind persons, who educators say are showing considerable interest in science, also may now learn about nuclear energy and its peaceful applications from specially produced Braille booklets. The AEC is working with the American Printing House for the Blind at Louisville, Ky., to print several booklets from the "Understanding the Atom" series in Braille. Nuclear topics and terms, not always readily translatable into conventional Braille, are made "seeable" by raised line diagrams or "Illustration" as shown *below*. The Braille books are available at nominal prices through the American Printing House for the Blind.



Biomedical and Physical Science

- Two helium-3 medical cyclotrons were in operation and a third was under construction at yearend. These are used for making very short-lived radioisotopes which are not ordinarily available for metabolic research or diagnostic studies.
- About 40 noteworthy advances in the fields of biomedical and physics research are "highlighted" from the supplemental report "Fundamental Nuclear Energy Research—1969." Work continued under nearly 1,200 biomedical and physical science research projects at some 200 colleges, universities, and other research institutions, in addition to the research conducted in AEC laboratory facilities.
- The Oak Ridge Electron Linear Accelerator (ORELA) began operation during 1969. It will fill a gap which has existed in neutron cross section measurements between low energy work at Rensselaer (RPI), Troy, N.Y., and data at higher energies collected from Argonne and Oak Ridge Van de Graaff accelerators.
- Engineering design of the National Accelerator Laboratory's major facilities is 34 percent complete, while construction is 7 percent complete.

Industrial Participation

- Discussions of competition in the nuclear industry have continued between the AEC and the U.S. Department of Justice.
- The formation of the new Western Interstate Nuclear Compact (WINC) was well underway as 11 States passed legislation authorizing the compact which will provide for regional cooperation in nuclear matters and projects of mutual interest to the States.

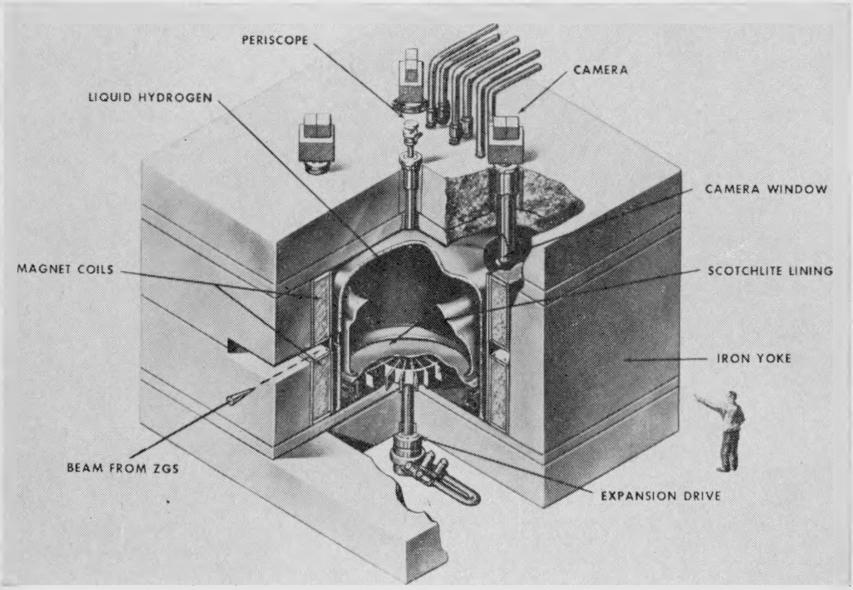
Administrative and Management Matters

- Participation in the Youth Opportunity Campaign by AEC contractors was at a new level, 23 percent above 1968. About 1,252 disadvantaged youth were employed during the summer compared to 1,016 in 1968.
- Since 1966, the training and technology project at the Oak Ridge (Tenn.) Y–12 Plant has trained nearly 1,000 unemployed or underemployed persons in job skills critically needed by modern industry.
- The disposal of three Government-owned communities—Oak Ridge, Richland, and Los Alamos, all built during World War II—has been virtually completed. In 1969, few vestiges of the once complete Government control of the communities remained.
- A central repository for radiation exposure records was estab-

The AEC's 1969 E. O. Lawrence Memorial Award was presented on April 30 to five U.S. scientists in ceremonies at the Carnegie Institution, Washington, D.C. The awardees are chosen by the Commission on the basis of recommendations made by its General Advisory Committee and with the approval of the President. Each of the recipients received a citation, a gold medal, and $5,000. The 1969 awardees were, *left* to *right:* John H. Nuckolls, Lawrence Radiation Laboratory, Livermore, Calif.—"for his contributions to the design of high efficiency thermonuclear devices, including minimum-fission explosives applicable to the Plowshare excavation program;" Dr. F. Newton Hayes, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.—"in recognition of his fundamental contributions to the development of scintillation counting which have been essential to the advancement of radiobiology and radiochemistry;" Dr. Ely M. Gelbard, Bettis Atomic Power Laboratory, Westinghouse Electric Co., Pittsburgh, Pa.—"for outstanding creative contributions in the development of modern methods of the design of nuclear reactors and for his deep insight into physical processes;" Dr. Don T. Cromer, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.—"for his outstanding contributions to the understanding of the structures of many intermetallic compounds of plutonium and other transuranic elements;" the fifth awardee (at speaker's stand) Dr. Geoffrey F. Chew, Lawrence Radiation Laboratory, Berkeley, University of California—"for his imaginative and creative contributions to progress in a wide range of problems in nuclear and elementary particle physics." Under the AEC seal, and to AEC Chairman Seaborg's left, is Dr. John H. Lawrence, Director of the Donner Laboratory, Berkeley, Calif., brother of the inventor of the cyclotron, Dr. E. O. Lawrence, in whose memory the awards are made. The annual Lawrence Award is made to recognize the current work being done by younger scientists in the Nation's atomic energy program; the 5 recipients each year are not more than 45 years old. The award was established in 1959.

lished during 1969 when certain radiation exposure information maintained by AEC licensees and contractors was centralized at the Computing Technology Center of AEC's Oak Ridge (Tenn.) Operations Office.

- During 1969, AEC prime contractors awarded over 42 percent of the subcontracts to small business concerns. AEC assistance to small business has averaged 42 percent of subcontract awards during the period 1951 through 1969.
- During its 5-year existence, the Board of Contract Appeals has docketed 66 appeals and one special proceeding.



The World's Largest Superconducting Magnet was rated by Industrial Research magazine as among the top 100 most significant technical developments of 1969. The liquid helium-cooled 110-ton magnet is shown in the cutaway diagram (*above*) of the 12-foot bubble chamber at Argonne National Laboratory. When energized the unique magnet can create a magnetic field 36,000 times greater than the earth's. The cutaway portion reveals the position of the super-conducting magnet relative to the central bubble chamber which contains 7,000 gallons of liquid hydrogen under pressure. The first nuclear particle tracks were observed in the bubble chamber in October 1969 from beams produced by the AEC's nearby Zero Gradient Synchrotron. The bubble chamber provides a new "tool" for basic research into the structure of elemental particles.

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT

[In Operation,* Under Construction, or Contractually Planned]

Plant (site)	Capacity [1] (net Mwe.)	Utility/owner	Startup
Alabama:			
Browns Ferry Nuclear Power Plant (Decatur)			
Unit 1	1,065	TVA	1971
Unit 2	1,065	do	1972
Unit 3	1,065	do	1972
Joseph M. Farley Nuclear Plant (Dothan)	829	Alabama Power Co	1974
Arkansas:			
Arkansas Nuclear One (London)	850	Arkansas Power & Light Co	1972
California:			
Malibu Nuclear Plant (Corral Canyon) Unit 1. [2]	462	Los Angeles Department of Water & Power.	1975
Diablo Canyon Nuclear Power Plant (near Avila)			
Unit 1	1,060	Pacific Gas & Electric Co	1972
Unit 2	1,060	do	1973
Humboldt Bay Power Plant (Eureka) *Unit 3.	69	Pacific Gas & Electric Co	1963
Rancho Seco Nuclear Generating Station (Clay Station)	800	Sacramento Municipal Utility District.	1972
*San Onofre Nuclear Generating Station Unit 1 (San Clemente).	430	Southern California Edison, San Diego Gas & Electric Co.	1967
Colorado:			
Fort St. Vrain Nuclear Generating Station (Platteville).	330	Public Service Co. of Colorado	1971
Connecticut:			
*Haddam Neck Plant (Haddam Neck)	575	Connecticut Yankee Atomic Power Co.	1967
Millstone Nuclear Power Station (Waterford).			
Unit 1	652	Millstone Point Co	1970
Unit 2	828	do	1973
Florida:			
Crystal River Plant (Red Level) Unit 3	858	Florida Power Corp	1972
Hutchinson Island (Fort Pierce) Unit 1	800	Florida Power & Light Co	1973
Turkey Point Station (Biscayne Bay)			
Unit 3	652	do	1971
Unit 4	652	do	1972
Georgia:			
E. I. Hatch Nuclear Plant (Baxley)	786	Georgia Power Co	1972
Illinois:			
Dresden Nuclear Power Station (Morris)			
*Unit 1	200	Commonwealth Edison Co	1959
Unit 2	809	do	1970
Unit 3	809	do	1970
Quad-Cities Station (Cordova)			
Unit 1	809	Commonwealth Edison, Iowa-Illinois Gas & Electric.	1970
Unit 2	809	do	1971
Zion Station (Zion)			
Unit 1	1,050	Commonwealth Edison Co	1971
Unit 2	1,050	do	1973
Indiana:			
Bailly Generating Station (Dunes Acres)	515	Northern Indiana Public Service Co.	1975

See footnotes at end of table.

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Continued

Plant (site)	Capacity [1] (net Mwe.)	Utility/owner	Startup
Iowa:			
Duane Arnold Energy Center. Unit 1 (Palo).	545	Iowa Electric Light & Power Co., Central Iowa Power Coop., and Corn Belt Power Coop.	1973
Maine:			
Maine Yankee Atomic Power Plant (Wiscasset).	790	Maine Yankee Atomic Power Corp.	1972
Maryland:			
Calvert Cliffs Nuclear Power Plant (Lusby)			
Unit 1	800	Baltimore Gas & Electric Co	1972
Unit 2	800	do	1973
Massachusetts:			
Pilgrim Station (Plymouth)	625	Boston Edison Co	1971
*Yankee Nuclear Power Station (Rowe)	175	Yankee Atomic Electric Co	1960
Michigan:			
*Big Rock Point Nuclear Plant (Big Rock Point).	70	Consumers Power Co. of Mich	1962
Donald C. Cook Plant (Bridgman)			
Unit 1	1,054	Indiana & Michigan Electric Co	1972
Unit 2	1,060	do	1973
*Enrico Fermi Atomic Power Plant (Lagoona Beach).	61	Power Reactor Development Corp.	1963
Unit 2	1,123	Detroit Edison Co	1973
Midland Nuclear Power Plant (Midland)			
Unit 1	[3] 492	Consumers Power Co. of Mich	1973
Unit 2	[3] 818	do	1974
Palisades Nuclear Power Station (South Haven).	700	do	1970
Minnesota:			
*Elk River Nuclear Plant	22	Rural Cooperative Power Association and AEC	1962
Monticello Nuclear Generating Plant (Monticello).	545	Northern States Power Co	1970
Prairie Island Nuclear Generating Plant (Red Wing).			
Unit 1	530	do	1972
Unit 2	530	do	1974
Nebraska:			
Cooper Nuclear Station (Brownville)	778	Consumers Public Power Dist	1971
Fort Calhoun Station (Ft. Calhoun) Unit 1	457	Omaha Public Power District	1971
New Hampshire:			
Seabrook Nuclear Station (Seabrook)	860	Public Service Co. of New Hampshire and United Illuminating Co.	[4]
New Jersey:			
Oyster Creek Nuclear Power Plant (Toms River)			
*Unit 1	515	Jersey Central Power & Light Co	1969
Unit 2	1,100	do [5]	1976
Salem Nuclear Generating Station (Salem)			
Unit 1	1,050	Public Service Electric & Gas Co., Philadelphia Elec. Co., ACEC & Delmarva P&L Co.	1971
Unit 2	1,050	do	1972
Unnamed (Newbold Island).			
Unit 1	1,100	Public Service Electric & Gas Co	1975
Unit 2	1,100	do	1977

See footnotes at end of table.

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Continued

Plant (site)	Capacity [1] (net Mwe.)	Utility/owner	Startup
New York:			
Bell Station (Lansing)	838	New York State Electric and Gas Corp.	(4)
Indian Point Station (Buchanan).			
*Unit 1	265	Consolidated Edison Co.	1962
Unit 2	873	do	1970
Unit 3	965	do	1973
*Nine Mile Point Nuclear Station (Scriba)	500	Niagara Mohawk Power Corp	1969
*R. E. Ginna Nuclear Power Plant (Ontario) Unit 1.	420	Rochester Gas & Elec. Co	1969
Shoreham Nuclear Power Station (near Rocky Point, Long Island).	819	Long Island Lighting Co	1975
Unnamed (Verplanck)	1,115	Consolidated Edison Co. [5]	1975
James A. FitzPatrick Nuclear Power Plant (Scriba).	821	Power Authority of State of New York.	1973
North Carolina:			
Brunswick Steam Electric Plant (Southport).			
Unit 1	821	Carolina Power & Light Co	1973
Unit 2	821	do	1975
Unnamed (site not announced)	821	do	1975
Unnamed (site not announced)	1,100	Duke Power Co	1977
Unnamed (site not announced)	1,100	do	1979
Ohio:			
Davis-Besse Nuclear Power Station (Oak Harbor).	872	Toledo Edison Co. and Cleveland Electric Illuminating Co.	1974
Wm. H. Zimmer Nuclear Power Station Unit 1 (Moscow).	810	Cincinnati Gas & Electric Co., Columbia and Southern Ohio Electric Co. and Dayton Power & Light Co.	1974
Oregon:			
Trojan Nuclear Plant (Prescott) Unit 1	1,106	Portland Gen. Electric Co., Eugene Water and Electric Board, and Pacific Power and Light.	1974
Pennsylvania:			
Beaver Valley Power Station (Shippingport) Unit 1	847	Duquesne Light Co. & Ohio Edison Co	1972
Peach Bottom Atomic Power Station			
*Unit 1	40	Philadelphia Electric Co	1966
Unit 2	1,065	Philadelphia Electric Co., Public Service Electric & Gas Co., AC-EC, & Delmarva P. & L. Co.	1971
Unit 3	1,065	do	1972
*Shippingport Atomic Power Station	90	Duquesne Light Co. & AEC	1957
Three Mile Island Nuclear Station (Goldsboro) Unit 1	831	Metropolitan Edison Co	1971
Unit 2	810	Jersey Central Power & Light Co	1974
Unnamed (site not announced)	1,052	Pennsylvania Power & Light Co	1975
Do	1,052	do	1977
Limerick Generating Station			
Unit 1	1,065	Philadelphia Electric Co	1975
Unit 2	1,065	do	1977
South Carolina:			
H. B. Robinson S.E.Plant (Hartsville) Unit 2	700	Carolina Power & Light Co	1970
Oconee Nuclear Station (Seneca)			
Unit 1	841	Duke Power Co	1970
Unit 2	886	do	1971
Unit 3	886	do	1972

See footnotes at end of table.

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Continued

Plant (site)	Capacity [1] (net Mwe.)	Utility/owner	Startup
Tennessee:			
Sequoyah Nuclear Power Plant (Daisy)			
Unit 1	1,124	TVA	1973
Unit 2	1,124	do	1974
Vermont:			
Vermont Yankee Generating Station (Vernon)	514	Vermont Yankee Nuclear Power Corp.	1971
Virginia:			
North Anna Power Station (Mineral) Unit 1	845	Virginia Electric & Power Co. [5]	1973
Surry Power Station (Gravel Neck)			
Unit 1	780	do	1971
Unit 2	780	do	1971
Wisconsin:			
Kewaunee Nuclear Power Plant (Carlton) Unit 1.	527	Wisconsin Public Service Co., Wisconsin P. & L. Co., and Michigan Gas & Electric Co.	1972
*LaCrosse Boiling Water Reactor (Genoa)	50	Dairyland Power Coop. & AEC	1967
Point Beach Nuclear Plant (Two Creeks)			
Unit 1	497	Wisconsin Electric Power Co. and Wis.-Mich. Power Co.	1970
Unit 2	497	do	1971

*Plants that were, or had been, operable as of December 31, 1969. Listing does not include the Nation's first dual-purpose reactor plant, the AEC's "N" reactor at the Hanford Works, near Richland, Wash. Steam created in the AEC's plutonium producing "N" reactor is drawn off for use in the adjacent WPPSS 790 Mwe. electric power generators—as such, this facility is not in the same category as the other plants listed in this table. Single-purpose plutonium production started in 1964 (the reactor had achieved initial criticality on 12/31/63); electricity generation began on April 8, 1966.

[1] Electrical capacities are the planned initial operating power levels, or the currently authorized power levels for plants now in operation.

[2] At year's end, the application was inactive.

[3] Unit 1 of the Midland Plant will also produce 3.6 million pounds per hour of process steam; Unit 2, 0.4 million lbs./hr.

[4] Utility announced indefinite postponement.

[5] Utility has option for second identical unit at same site.

Chapter 1

SOURCE, SPECIAL, AND BYPRODUCT NUCLEAR MATERIALS

URANIUM SUPPLY

Exploration activity again reached new record high levels during the year, and resulted in substantial increases in uranium ore reserves particularly in Wyoming, Texas, and New Mexico.

RAW MATERIALS

Uranium Procurement

During 1969, the AEC purchased from domestic producers 6,140 tons of U_3O_8 in uranium concentrate under existing contracts out of a total estimated production of 12,200 tons. The purchase price paid under each contract is determined by the formula: 85 percent of allowable production costs per pound of U_3O_8 during the 1963–68 period plus $1.60 with a maximum price of $6.70. Based upon information compiled to date, the weighted average price per pound of U_3O_8 delivered to the AEC in 1969–70 is estimated at $5.86. AEC contracts with six uranium milling companies were modified, reducing the quantity of uranium to be purchased during 1969 and 1970 by about 4,000 tons of U_3O_8 in uranium concentrate. As a result of earlier cutbacks in the production of fissionable materials, and after making provision for foreseeable Government requirements, the AEC will have an estimated surplus of about 50,000 tons of U_3O_8 in concentrates upon completion of the remaining uranium purchase contracts. All uranium purchased by the AEC was received at Grand Junction, Colo., where weighing, sampling, and analysis for payment purposes is performed for the AEC by Lucius Pitkin, Inc.

Commercial Uranium Market

Commercial deliveries by U.S. uranium producers amounted to 4,750 tons, or 44 percent of the total sales during 1969. Commercial sales commitments for delivery in the 1970–82 period are approximately 67,600 tons. Of this amount a total of 1,300 tons is committed to overseas customers.

During 1969, the domestic nuclear power industry leased enriched uranium equivalent to 1,640 tons of U_3O_8 from the AEC. At year's end, the natural uranium component of the enriched material on lease was 4,600 tons of U_3O_8. In general, the uranium on lease must be converted to private ownership by July 1, 1973, under the Private Ownership of Special Nuclear Materials Act of 1964.[1] No new distribution of commercial uranium for power reactor fuel under the AEC's leasing program will be made after 1970.

Toll enriching of privately owned uranium in the AEC's three enriching facilities became available on January 1, 1969. By the end of the year, 25 toll enriching contracts had been signed. The quantity of uranium hexafluoride (UF_6) delivered to the AEC for toll enriching during the year was equivalent to 5,850 tons of U_3O_8.

While large additional uranium sales will be needed to meet the requirements of the nuclear power industry after the mid-1970's, the near-term market is reported by producers and consumers to be largely

[1] See pp. 12–15, "Annual Report to Congress for 1964."

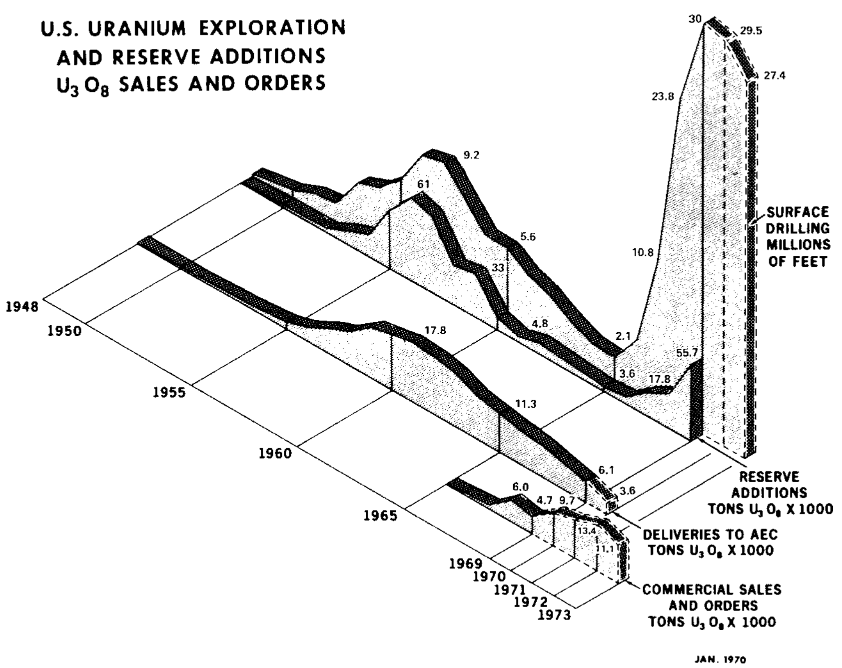


TABLE 1.—U.S. COMMERCIAL URANIUM COMMITMENTS AND REQUIREMENTS*

(In tons U_3O_8)

Year	Delivery commitments		Projected requirements (cumulative)
	Annual	Cumulative	
Pre-1969	5,700	5,700	
1969	4,300	10,000	4,000
1970	9,000	19,000	11,500
1971	11,000	30,000	19,000
1972	13,200	43,200	30,000
1973	10,900	54,100	43,500
1974	8,900	63,000	58,700
1975	6,400	69,400	75,900
1976	2,700	72,100	96,300
1977	1,900	74,000	120,000
1978–1982	3,600	77,600	292,500

*As of September 1969; latest figures available.

satisfied. Construction schedule delays on some reactors have resulted in a buildup of substantial consumer uranium inventories.

The production capability of the domestic uranium industry is increasing. Dawn Mining Co., whose mine and mill near Spokane, Wash., has been closed since 1965, prepared to resume production. Utah Construction & Mining Co. is building a new mill in the Shirley Basin in Wyoming, and Petrotomics Co. is expanding its mill located in the same area; Susquehanna-Western, Inc., is constructing a mill in Texas. However, Western Nuclear has announced postponement of construction of a new mill in Washington which was previously scheduled for operation by January 1971.

The presently operating mills, mills under construction, on standby, and planned are listed in table 2.

Ore Reserves

U.S. uranium ore reserves at $8 per pound of U_3O_8 increased during 1969 as follows:

	Tons of ore	Percent U_3O_8	Contained tons U_3O_8
Reserves January 1, 1969	70,000,000	0.23	161,000
Reserves December 31, 1969	97,000,000	0.21	204,000
Net change during 1969	27,000,000	0.16	43,000

Estimated reserves of 55,700 tons of U_3O_8 recoverable at $8 per pound were developed in 1969; 12,700 tons were mined and delivered to mills. The net increase in $8 reserves at yearend was 43,000 tons, the largest net addition to reserves in any single year since 1957. Substan-

TABLE 2.—URANIUM MILLING PLANTS IN THE UNITED STATES

Company	Plant location	Nominal capacity—tons ore per day
American Metal Climax, Inc.	Grand Junction, Colo.	500
The Anaconda Co.	Bluewater, N. Mex.	3,000
Atlas Corp.	Moab, Utah	1,500
Cotter Corp.	Canon City, Colo.	400
Dawn Mining Co.	Ford, Wash.	[1] 450
Federal-American Partners	Gas Hills, Wyo.	900
Kerr-McGee Corp.	Grants, N. Mex.	6,000
Mines Development, Inc.	Edgemont, S. Dak.	650
Petrotomics Co.	Shirley Basin, Wyo.	[2] 1,000
Susquehanna-Western, Inc.	Falls City, Tex.	1,000
Susquehanna-Western, Inc.	Ray Point, Tex.	[3] 1,000
Union Carbide Corp.	Rifle, Colo. }	1,500
Union Carbide Corp.	Uravan, Colo. }	
Union Carbide Corp.	Gas Hills, Wyo.	1,000
United Nuclear-Homestake Partners	Grants, N. Mex.	3,500
Utah Construction & Mining Co.	Gas Hills, Wyo.	1,200
Utah Construction & Mining Co.	Shirley Basin, Wyo.	[3] 1,200
Western Nuclear, Inc.	Jeffrey City, Wyo.	1,200
Pinnacle Exploration, Inc.	Marshall Pass, Colo.	[4] ------
Total		26,000

[1] Start of operation early in 1970.
[2] Expansion to 1,500 tons per day to be completed early in 1970.
[3] Under construction.
[4] Concentrate recovery from recirculating mine water—TPD not applicable.

tial reserve increases occurred in areas served by existing mills .There was also a large reserve increase in the Powder River Basin of Wyoming, which appears capable of developing into a major uranium district. Calculated yearend ore reserves ($8 per pound of U_3O_8) by States were:

	Tons of ore	Percent U_3O_8	Contained tons U_3O_8
New Mexico	34,900,000	.25	86,000
Wyoming	44,000,000	.19	82,300
Colorado	2,600,000	.28	7,100
Utah	3,000,000	.32	9,500
Texas	3,800,000	.18	7,000
Others	8,700,000	.15	12,100
Total	97,000,000	.21	204,000

Reserves recoverable at $10 per pound are estimated to be 370,000 tons of U_3O_8. This includes an estimated 120,000 tons which could be recovered as a byproduct from copper and phosphate production through the year 2000. However, there is no uranium being produced from these byproduct sources now, and no production plans have been announced. At the end of the year, primarily because of the high rate of drilling, there was a substantial backlog of unevaluated information. Also, the data from some of the 1969 drilling was not yet available to the AEC. The analysis of these data is expected to increase the estimated reserves by about 50,000 tons of U_3O_8, principally in Wyoming, New Mexico, and Texas.

The uranium inventories of the producing mills at yearend included, 400 tons in stockpiles of ore, and 4,700 tons in material being processed and in finished product inventories.

Potential Resources

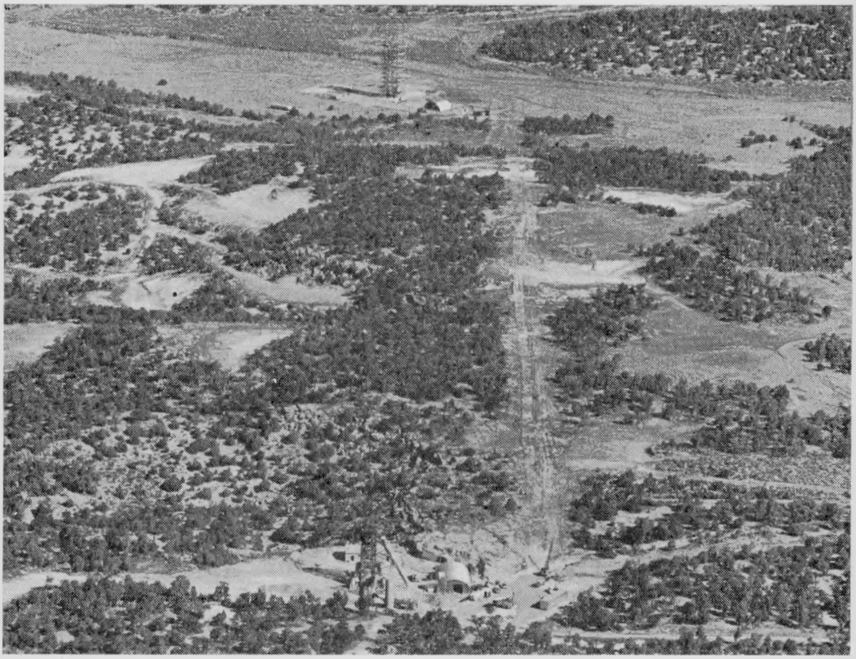
Numerous situations exist in which there is the likelihood of future ore development—varying from unexplored areas adjacent to known ore bodies to those where the geology is favorable but little or no direct evidence of uranium is available. Based on past experience in similar areas, estimates of the potential for future uranium discoveries are made from time to time; much of the 1969 ore reserve development was in such areas. An important development during the year was the increase in the estimate of potential resources in addition to the increase in known reserves. The estimate of potential resources in the Western U.S. increased from 350,000 to 600,000 tons of U_3O_8. Such estimates are not of a comparable degree of reliability with estimates of ore reserves, but they do provide a useful measure of potential supply in areas favorable for conducting further exploration.

Exploration Activity

At mid-year, an AEC survey of industry drilling plans showed that a total of 110 million feet of drilling was planned for the period 1969–72, including 29,400,000 feet for 1969. Actual 1969 footage drilled was 30 million feet, compared with 23,800,000 in 1968, and 10,800,000 in 1967. Industry plans indicate that drilling will probably be continued at about the current level in 1970. The chart shows past surface drilling activity and reported industry plans for the future, the U_3O_8 content of the developed reserve, and the reserve addition by years.

Foreign Uranium Enrichment and Surplus Disposal

At year's end, the AEC had under consideration ways by which it might modify the restriction on the enrichment of foreign uranium intended for domestic use in the United States, and how it might carry



A Deeply Buried Uranium Ore Body was under preparation for mining by Rio Algom Corp., of Toronto, Canada, in the Lisbon Valley area near Moab, Utah, during 1969. In the background of photo *above*, is the head frame where an 18-foot diameter, 2,700 foot-deep production shaft is being sunk. It will be the deepest shaft to be sunk to date in the United States for the production of uranium. In the foreground, an 18-foot diameter ventilation shaft is being sunk which will serve as the mine's exhaust and emergency exit. Completion of the mine's development is expected in 1972. A mill at the location is planned to treat the ores. Photo *below* shows overburden being stripped at the Dave pit of the Petrotomics Co., in the Shirley Basin, Wyo., prior to mining of the underlying uranium ore body. The shovel, with a 17-cubic yard bucket capacity, can strip 30,000 cubic yards of earth a day and has the largest capacity in use in Wyoming.

out the future disposal of AEC-owned surplus uranium. The restriction now in effect on enrichment of foreign uranium was established pursuant to subsection 161 v. of the Atomic Energy Act of 1954 to help assure the maintenance of a viable domestic uranium industry. In a supply policy statement of September 1968, the AEC indicated that the removal of such restrictions might be possible by June 1973 or earlier. It also indicated that removal on a graduated basis might be desirable. With respect to AEC surplus uranium, the policy statement noted that: "* * * While quantitative criteria could not be specified, the disposal of AEC's available feed stocks would not be undertaken until it could be done in a manner which would not adversely affect the general viability of the domestic uranium industry."

It is anticipated that proposals relating to the relaxation of restrictions on the enrichment of foreign uranium and the disposal of the AEC surplus may be issued for public comment in 1970.

Training Activities

The AEC's Grand Junction Office periodically holds 3-day industry training sessions or workshops. Members of the AEC staff give talks and conduct discussions on uranium geology, geochemistry, exploration technology, ore reserve analysis, mining and milling methods, and economics to the 50–60 persons at each session. During 1969, about 590 persons attended 7 such workshops. During the past 3 years, 1,647 persons representing 429 companies or other organizations and 175 self-employed consultants have attended. Attendees primarily represent companies with activities directly related to uranium production; however, persons employed by investment companies, banks, utilities, reactor manufacturers, universities, and State governments have also attended.

URANIUM ENRICHMENT

A new forecast of nuclear power at home and abroad and the corresponding needs for enriched uranium was made by the AEC during the year. The capacity of nuclear powerplants to be in commercial operation by the end of calendar year 1980 in the United States was estimated at about 150,000 electrical megawatts (Mwe.), about the same as the AEC's 1967 forecast. A reasonable range appears to be 130,000 to 170,000 Mwe. The corresponding range for foreign plants in the Free World (other than those in the United Kingdom) to be fueled with enriched uranium is 80,000 to 110,000 megawatts. In these forecasts, account was taken of slippages in dates initially projected by utilities for starting commercial operation of powerplants. The computation of requirements for enriched uranium made allowances for lead times in procuring fuel and for future improvements in operating characteristics of nuclear powerplants and also showed the effect of plutonium recycle.

ENRICHMENT FACILITY MANAGEMENT

On November 10, 1969, the President announced his decision that the Government-owned uranium enrichment facilities are to be conducted by a separate organizational entity within the AEC in a manner more closely approaching a commercial enterprise. The decision contemplates that responsibility for uranium enrichment ultimately will be transferred to the private sector at a time, and in a manner, which would best serve the national interest. During the interim period, the

Thought to be the Largest Uranium Ingot Ever Cast in the free world from a single melt in one furnace, the ingot shown on *left* was 13 inches in diameter, more than 48 inches high, and weighed about 4,800 pounds. The casting was made at the AEC's Fernald (Ohio) Feed Materials Production Center, operated by the National Lead Co. of Ohio. Photo on *right* shows an enriched uranium foil (*dark* strip) being inserted into a stainless steel envelope at the Oak Ridge (Tenn.) Y–12 Plant prior to shipment to Argonne National Laboratory for use in nuclear reactor experiments. The foil, only .021-inch thick, is one of 34 strips fabricated for the project. The Y–12 Plant, operated by Union Carbide Corp., Nuclear Division, for the AEC, was selected to perform the job because of the plant's unique facilities for handling enriched uranium.

AEC will continue to supply enriched uranium and uranium enrichment services to domestic and overseas users including the fulfillment of all existing commitments.

Earlier during the year, the Executive Office of the President had established a task force consisting of the Chairman of the Council of Economic Advisers, representatives of the Bureau of the Budget, Office of Science and Technology, Departments of Justice, Treasury, and State, and the AEC to consider the question of future disposition of AEC's uranium enrichment facilities. A task force report analyzing the issues and the advantages and disadvantages of the various alternatives for future ownership and management of these facilities was submitted to the President on August 29, 1969.

Separate AEC Directorate To Be Formed

The new entity, which will be an AEC directorate, will maintain separate accounting records and will publish periodic financial reports similar to those of commercial enterprises. Such reports will reflect the financial results of operating the uranium enriching enterprise, and also will provide information needed for financial analysis and investment decisions when the sale of these facilities to the private sector is considered. The facilities involved are the gaseous diffusion plants at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio.

The uranium enriching enterprise will be funded with revenues from its sales, supplemented, as necessary, by appropriations through the normal budgetary process. To implement the Presidential decision, AEC studies are now underway to identify in detail the structure of the entity, its responsibilities, and its relationship to other AEC functions.

Government-Industry Studies Made

Prior to this Presidential decision, studies on the question of future responsibility for conducting the uranium enriching function in the United States, and the possible transfer of the gaseous diffusion plants to private ownership, were carried out by the AEC, a committee established by the Atomic Industrial Forum (AIF), and the General Accounting Office. Hearings were held by the Joint Committee on Atomic Energy (JCAE).

The AEC study included consideration of the question of transfer of the existing gaseous diffusion plants to private industry or to a Government corporation, as well as the question whether industry or the Government should have the responsibility for making the large financial expenditures that will be necessary in the 1970's and early 1980's to construct the new uranium enriching facilities that will be required to meet future needs.

An AEC staff summary report, "Future Ownership and Management of Uranium Enrichment Facilities in the United States," issued in March 1969, identified and discussed the primary factors involved in the Government's consideration of the question, and identified a spectrum of alternatives ranging from continued Government ownership within the AEC to the complete transfer of all existing enrichment facilities to private industry as soon as practicable. This summary report and background information on the subject was supplied to other Government agencies having an interest in the matter, to selected groups of executives of U.S. industry, and to representatives of many countries that are, or may in the future be, involved in the nuclear industry.

The AEC staff report, the GAO report, and a report of the AIF study committee dated June 1968, plus industry and other parties' comments on the AEC staff report, were compiled into a JCAE document entitled "Selected Materials Concerning Future Ownership of the AEC's Gaseous Diffusion Plants." It was issued [2] in June 1969, prior to the JCAE's initial hearings on this subject. The JCAE hearings were held on July 8 and 9, 1969, to receive AEC and GAO testimony, and on August 5, 7, and 8, 1969, for testimony by industry representatives.

Toll Enriching Services

Toll enriching services [3] in the AEC's three gaseous diffusion plants were made available to domestic and foreign customers beginning January 1, 1969. The services provided to the customers under toll enriching contracts are expressed in terms of kilogram units of separative work.[4] During this first year of the program, the AEC re-

[2] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 at $2 a copy.

[3] Uranium enrichment is done at the AEC's contractor-operated gaseous diffusion plants in Kentucky, Ohio, and Tennessee. Uranium hexafluoride (UF_6), in a gaseous state, is put through a series of barriers, which partially separate the lighter and faster-moving uranium-235 (U^{235}) atoms from the heavier and slower-moving uranium-238 atoms that make up the bulk of the material. Under "toll enrichment"—which began in 1969—the customer supplies uranium feed and gets back as product, a lesser amount of uranium containing a greater concentration of the U^{235}, and optionally, the rest of the uranium (tails) containing a lesser concentration of U^{235}. For this service the AEC levies an enrichment service charge, or "toll," upon the industrial customer.

[4] A "separative work unit" is a measure of the effort expended in the plants to separate a quantity of uranium into a portion enriched in uranium-235 (U^{235}) and a portion depleted in U^{235}. The number of separative work units required to produce enriched uranium for fuel for any specific nuclear powerplant is related to the concentration of uranium-235 required, the concentration of the feed material, and the waste (tails) concentration.

ceived revenues in the amount of approximately $49.6 million for 1.909 million units of separative work sold. At the end of the year, 8 contracts had been signed with domestic customers to provide an estimated 20.8 million units of separative work through 1998, and 17 contracts had been signed with foreign customers to provide approximately 15.4 million units of separative work through the year 2008 (see table 3). The current AEC charge for enriching services is $26 per kilogram unit of separative work.

To encourage current sales of normal uranium by domestic suppliers and to increase near-term revenues to the AEC, the Commission authorized *in situ* (in place) toll enriching to begin in April 1969, instead of January 1, 1971, as had been earlier planned.[5] This transaction is a method whereby a lessee can acquire ownership of leased enriched uranium by furnishing, as payment, required amounts of uranium feed and dollars. Through December 1969 the AEC had received over $11.2 million from this source. The policy acceleration, along with two increases in the use-charge on leased materials (from 5.5 percent to 6.5 percent in April and to 7.5 percent in November), had the effect of increasing the motivation for power reactor operators to adopt private ownership of nuclear fuel and the associated purchase of enriching

TABLE 3.—TOLL ENRICHING SERVICE AGREEMENTS

(As of December 31, 1969)

	Amounts of separative work	
	In kilogram units	At $26/unit
Domestic Customers—Signed Contracts:		
Babcock & Wilcox	203, 069	$5, 279, 794
Commonwealth Edison (2 contracts)	8, 276, 414	215, 186, 764
General Electric	801, 493	20, 838, 818
Kerr-McGee	366, 382	9, 525, 932
Philadelphia Electric Co	7, 193, 760	187, 037, 760
Westinghouse	498, 324	12, 956, 424
Sacramento Municipal Utility District	3, 436, 234	89, 342, 084
Total Domestic	20, 775, 676	540, 167, 576
Foreign Customers—Signed Contracts:		
Germany (9 contracts)	2, 991, 462	77, 778, 012
Netherlands	24, 548	638, 248
France	200, 000	5, 200, 000
Japan (4 contracts)	8, 160, 198	212, 165, 148
Sweden	1, 622, 169	42, 176, 394
Switzerland	2, 413, 519	62, 751, 494
Total Foreign	15, 411, 896	400, 709, 296
Grand Total	36, 187, 572	940, 876, 872

[5] See pp. 12–15, "Annual Report to Congress for 1964."

services in preference to leasing, and thereby helping to provide a market for the U_3O_8 made available by reduced purchases under existing AEC procurement contracts.

NUCLEAR MATERIALS PRODUCTION

Production of special nuclear materials continued at levels established to meet military and civilian program requirements. Studies of how best to meet future enriched uranium demands of the nuclear power industry were continued.

PRODUCTION OPERATIONS

The achievement of the best integrated use of nuclear materials production facilities has required increased planning effort. The ratio of civilian demands to military demands on these production facilities is shifting. The fact that economic and technical decisions must be made now, in the face of long lead-times for electric power commitments and new plant capacity will continue to underline the importance of advanced planning. Analysis of the impact of possible changes in gaseous diffusion ownership or management has added another dimension to the already complex problem of integrating production operations.

Studies are continuing to determine the most efficient use of present resources to meet projected requirements for enriched uranium. The existing enriched uranium production capacity at Oak Ridge, Paducah, and Portsmouth meets present needs, but additional enriching capacity will be needed by the late 70's or early 80's to meet the growing civilian market.

The production reactors at the Savannah River plant are being utilized to produce multiple products; reactor operations at the Hanford Works are aimed primarily at producing plutonium.

Gaseous Diffusion Plant Operations

During 1969, the total electric power level at the AEC's three gaseous diffusion plants (Oak Ridge, Portsmouth, and Paducah) was reduced by 215,000 kilowatts. This reduction represented the final step of the previously scheduled power cutbacks [6] to reduce the total power level

[6] See p. 34, "Annual Report to Congress for 1968," and pp. 35–36, "Annual Report to Congress for 1967."

of the plants to 2 million kilowatts. This level of operation is expected to continue into 1970. Power increases, scheduled to start in fiscal year 1971 (July 1, 1970–June 30, 1971), have been contracted for to provide the additional uranium enriching capacity needed to meet the projected future civilian nuclear power reactor fuel requirements.

The gaseous diffusion complex continued to operate in series and overlap with the product from the Paducah plant being shipped to the Oak Ridge and Portsmouth facilities for further enrichment. Various assays continued to be withdrawn from both Oak Ridge and Portsmouth with all high-assay products being produced at the Portsmouth plant.

Reactor Operations

On April 25, 1969, Hanford's "C" reactor was placed in standby status; it was the eighth production reactor to be shut down by the AEC since early 1964. The six production reactors still in active operation—three each at Hanford and Savannah River—continued to perform at satisfactory levels during 1969.

Hanford Reactors

"N" Reactor Operation. The "N" reactor [7] continued production of plutonium and byproduct steam for electrical power generation. The electrical power output of the Washington Public Power Supply System (WPPSS) generating station, which uses byproduct steam from the reactor was about 3,800 million kilowatt hours (kw.-hr.) during 1969. The total 3½-year output from this station has been about 10,800 billion kw.-hr., the highest output of any single nuclear power station in the world. Generation was curtailed somewhat in 1969 by an extended maintenance outage of the reactor during July and August. This outage was part of an extensive and comprehensive preventative maintenance program to improve the operating-time efficiency of the reactor. The "N" reactor has also increased the rate of neptunium-237 production by using fuel elements with higher than normal concentrations of uranium-236.

"K" Reactors Operations. In addition to the uranium-233 and plutonium-239 produced in the two Hanford "K" ("KE" and "KW")

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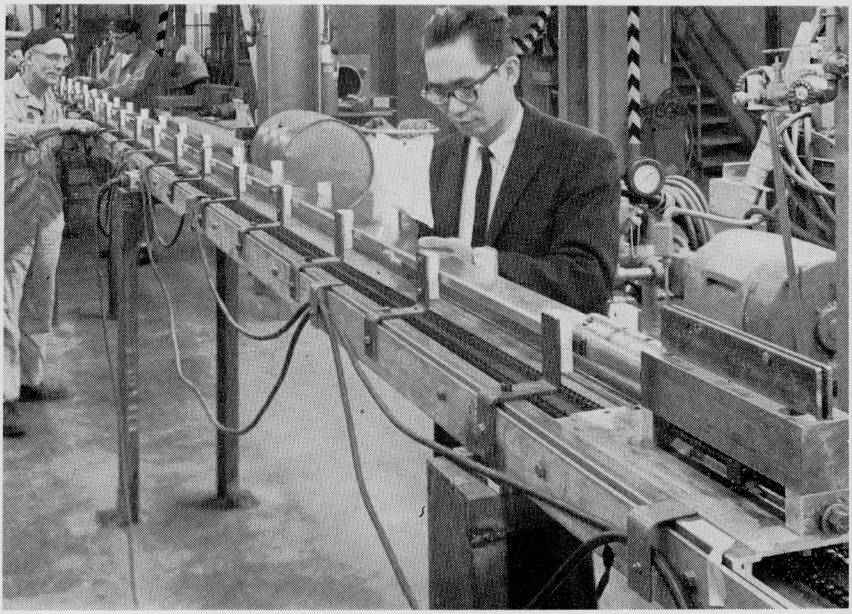
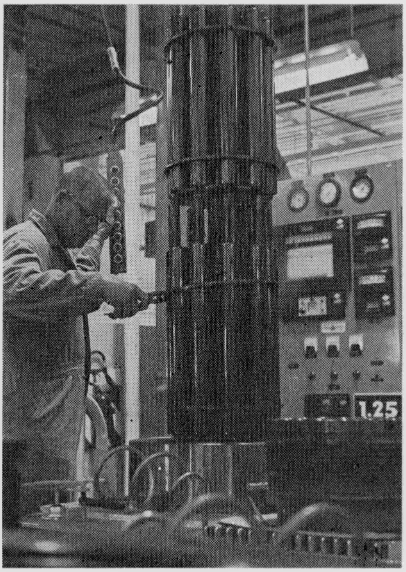
[7] The "N" reactor was built as the Nation's first dual-purpose reactor plant; steam generated in the AEC's plutonium producing reactor plant is drawn off for use in the adjacent WPPSS electric power generators—as such, this facility is not in the same category as the other plants listed in Table 1—Central Station Nuclear Powerplants, of the Introductory Chapter. Single-purpose plutonium production started in 1964; electricity generation began in April 1966.





Two New Types of Fuel Rods have been developed for use in the Hanford production reactors. An uncooled reactor control rod (*above*), consisting of 12 articulated segments containing the rare earth metal, dysprosium, has been tested successfully in the "KE" reactor operated for the AEC by Douglas United Nuclear at the Hanford Project. At *left* is a new model fuel element containing about 12 percent more uranium for the same length being used in the "N" reactor at Hanford. Thermal hydraulics and physics performance tests met expectations, and the new Mark IV model went into production in the "N" reactor fuel fabrication facility operated for the AEC by Douglas United Nuclear. Gradual transition to operation on the new fuel element is taking place.

reactors, quantities of neptunium-237 and high-purity (low Pu^{236} content) plutonium-238 have been produced. Continued attention is being given to the development of methods of insuring the production of large quantities of this high-purity plutonium-238.

The "K" reactors also contain a total of 50 in-pile irradiation facilities of various sizes in which specialty irradiations are performed in support of AEC, NASA, and Department of Defense development programs.

Savannah River Reactors

Reactor production of weapons grade plutonium and tritium continued through 1969. Other reactor products included uranium-233, neptunium-237, polonium-210, plutonium-238, fuel-grade plutonium (containing up to 21% Pu-240), and transplutonium elements.

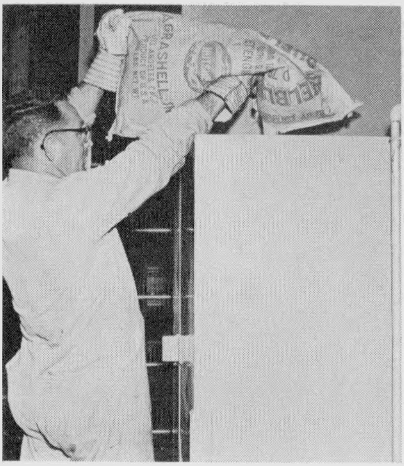
Californium-252

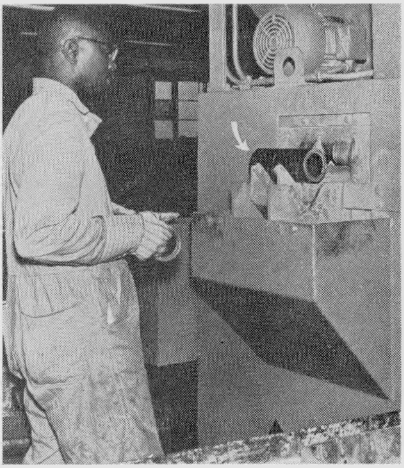
A vigorous program to produce up to a gram of californium-252 (Cf^{252}) is in progress at Savannah River. This isotope has great potential value in a wide variety of uses in medicine, industry, research and education. It is an intense neutron emitter with a relatively long half-life (2.65 years). Compared to other present neutron sources, californium appears to have significant advantages—such as high neutron yield, low gamma radiation, insignificant heat from radioactive decay, and compactness. Studies to investigate possible applications and to evaluate the market for the isotope are underway; industry and science have shown a lively interest in the potential uses of californium-252. The broad range of uses is illustrated in the "tree" sketch (p. 53).

Market Development

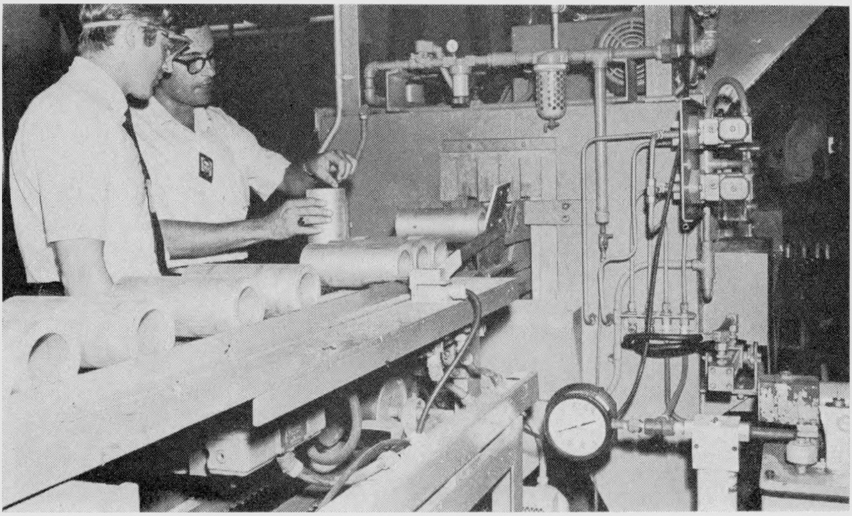
The AEC is currently loaning small, prototype californium-252 sources (up to one milligram [8]) to selected interested investigators

[8] A gram is about one-twenty-eighth of an ounce: a milligram is one-thousandth of a gram; and a microgram is one-millionth of a gram.





Ground-Up Walnut Shells are being used to clean nuclear fuel elements at the Savannah River Plant. The ground-up shells, resembling brown sugar, are used in a blast cleaning machine in a completely automated process. In *above left* photo, the shells go into a hopper; the fuel elements are dirty (note *arrow* in *right* photo) as they are fed to the machine; and they glisten as they come out (*below*). Each element (called a slug) remains in the machine for five and a half minutes, turning in 11 different positions. Whirling wheels throw the shells to clean the outside of the slug while a blast of compressed-air driven shells cleans the inside. Walnut shells do not erode the aluminum, the protective outer jacket of the slugs, as some chemicals do, and the automation of the process is an added safety precaution for the operator. The shell cleaning process is a plus factor in water and air pollution control, since it eliminates the nitric acid, associated with a previous process.



A Final Radioactivity Monitoring Check is made by a health physicist (*left*) on a spherical shipping cask before a shipment of californium-252 leaves the AEC's Savannah River Laboratory enroute to Texaco Inc.'s Bellaire, Texas, Laboratory where the material will be used in experiments to develop techniques for oil exploration. The californium is contained in a small, specially-designed capsule in the center of the cask, inside of which there is additional appropriate shielding. This shipment was the largest thus far in the AEC's nationwide market development program—a total of 703 micrograms. Texaco was the first commercial firm to sign (May 13, 1969) a contract with the AEC for loan of the material in the market development program. Texaco built its own truck-mounted transportation cask for the two (70 and 700 micrograms) sources it has borrowed. Prior to the actual loading of the highly radioactive sources, the operation was carefully rehearsed a number of times with a dummy source and holder; the source (*arrow* in *left* photo) is in a platinum metal matrix triply encapsulated in stainless steel.

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free of charge. In return, the investigators make available to the AEC the information they develop on the possible industrial applications and requirements for californium-252. Thirteen loan agreements are currently in effect with the following:

Investigator	Use	Number of sources
Argonne National Laboratory, Argonne, Ill	Neutron radiography	1
Brookhaven National Laboratory, Upton, L.I., N.Y.	Cancer therapy	77
Columbia Scientific Research Institute, Austin, Tex.	Impurities detection in ore	5
General Dynamics, Fort Worth, Tex.	Neutron radiography	1
Georgia Institute of Technology, Atlanta, Ga.	Educational	1
Geosensors, Inc., Dallas, Tex.	Mineral exploration	2
Hospital of University of Pennsylvania, Philadelphia	Cancer therapy	52
M. D. Anderson Hospital and Tumor Institute, Houston, Tex.	Cancer therapy	54
Republic Steel Corp., Cleveland, Ohio	In-process control	2
Schlumberger Technology Corp., Ridgefield, Conn.	Petroleum exploration	2
Texaco, Inc., Bellaire, Tex.	Petroleum exploration	2
U.S. Bureau of Mines (Dept. of the Interior), W. Va.	Analysis of sulfur content of bituminous coal.	2
U.S. Geological Survey (Dept. of the Interior)	Mineral exploration; oceanography	2

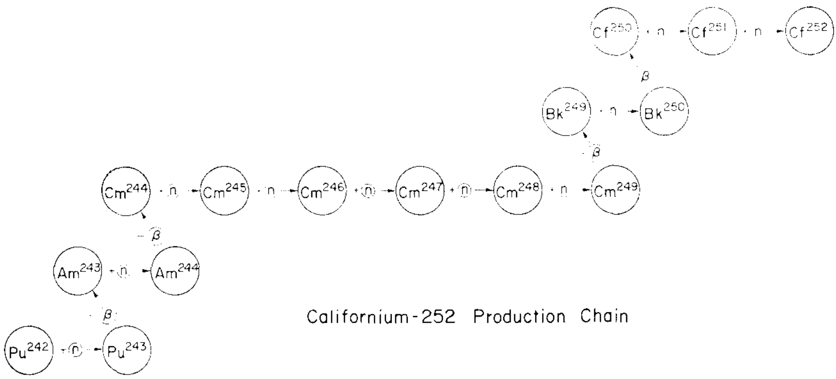
Through the Savannah River Operations Office, the AEC is actively seeking additional evaluation for californium-252. Proposals for investigations in process control, production of short-lived isotopes, commercial activation analysis, and training are also being considered.

As part of the market development program, the AEC issued a brochure, "Californium-252—Its Use and Market Potential," [9] which describes the characteristics of Cf^{252} and highlights of the loan program. Periodic supplements entitled "Californium-252 Progress" are to summarize the results of all investigations performed under the program and will also be used to record any new information regarding californium, such as new participants, the possible sale of the isotope, and the quantity of material produced and available. Printing of the first quarterly supplement was completed in October and the 1,500 copies were distributed. Requests were mostly from industrial organizations, with some 250 coming from educational and medical institutions. Before the end of the year, a second printing of 1,000 copies was necessary as requests continue to be received.

Production of Californium-252

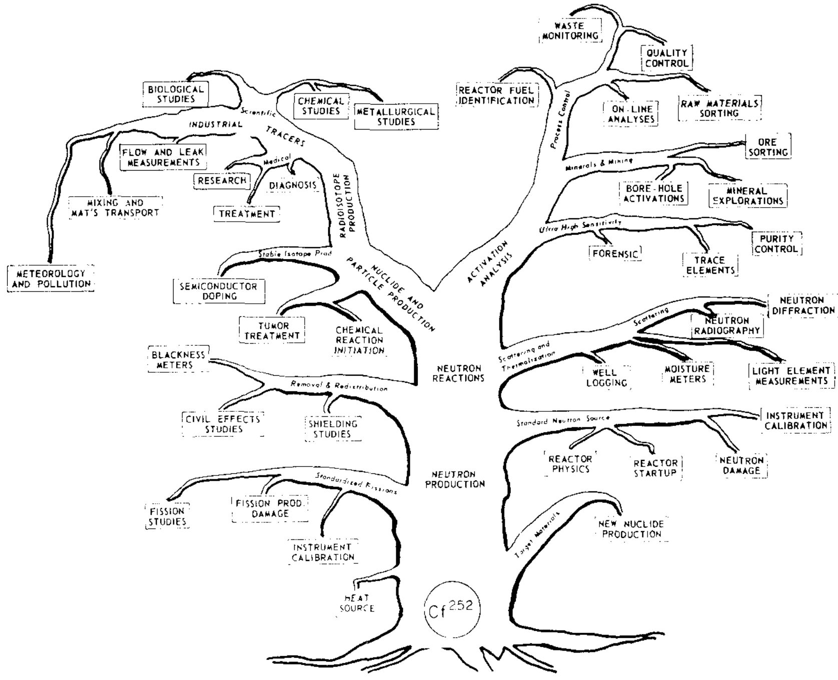
In early August, the first of two californium production campaigns (each is now expected to take about a year) was begun at Savannah River in a reactor operating in a high-flux mode. This campaign, in

[9] Available without charge from Savannah River Operations Office, U.S. Atomic Energy Commission, P.O. Box A, Aiken, S.C. 29801.



Californium-252 Production Chain

The Californium-252 "Story" will continue to grow as more of this man-made radioisotope becomes available for research and developmental uses. Industry and science are already showing a lively interest in the ever-broadening potential usefulness for this new product of the Savannah River Plant production reactors. The schematic *above* shows how plutonium-242 (Pu^{242}) is transmuted to californium-252 (Cf^{252}) through 10 neutron capture reactions (+Ⓝ) and four intermediate beta decays ($-\beta$). The sketch *below* illustrates the many uses to which californium-252 appears applicable. More than 2,000 copies of an October report on californium-252 have been distributed, upon request, by the AEC's Savannah River Operations Office.



Californium-252 USE TREE

which plutonium-242 is converted to californium-252 through 10 neutron captures interspersed with 4 beta decays, is expected to produce about a gram of californium, some of which may be available for loan under the market development program.

Heavy Water Production

During 1969, 197 tons of virgin heavy water were produced in the Savannah River heavy water plant. Heavy water sales continued to exceed the annual production thus reducing the AEC inventory of this product. Sales to U.S. customers, primarily for research use and for the manufacture of deuterium gas and deuterated compounds, totaled 5.3 tons, a 31 percent decrease from 1968 sales. Deliveries to foreign purchasers totaled 230 tons, a 6 percent decrease from the corresponding 1968 deliveries. In addition to these heavy water deliveries in 1969, heavy water commitments for foreign sales during the next 2–3 years exceeds 1,600 tons, including 767 tons for which prepayment of $40,250,000 has already been received. In December, the AEC announced an immediate increase in the sales price of heavy water from the $28.50 per pound in effect since May 1968 to $30.00 per pound due principally to general escalation of the operating costs for the heavy water plant.

Waste Management

The AEC chemical processing facilities at Hanford, Savannah River, and the National Reactor Testing Station (NRTS) in Idaho, concentrate and store radioactive waste material in large underground tanks or bins. At Hanford and Savannah River, the technique is to evaporate liquid wastes to very concentrated salt solutions and slurries which solidify to moist salt cakes as the liquids cool. The Idaho facility uses a fluidized bed process to evaporate and convert the liquid wastes to a granular calcine product having about one ninth of the original solution volume. The calcined product is sent to underground bins especially designed for heat dissipation during long-term storage.[10]

Savannah River Storage

Construction of four new high-level waste storage tanks[11] at the Savannah River Plant was completed during 1969. The inner carbon

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[10] See pp. 85–86, "Annual Report to Congress for 1965."

[11] See p. 45, "Annual Report to Congress for 1968."

steel tanks of these double steel-shell vessels were successfully stress relieved by heat treating after construction, making them the largest vessels ever to be so treated in the field.

Sufficient progress has been made in the investigation of the feasibility of storing radioactive wastes from the chemical separations plants in long caverns excavated in the crystalline bedrock, some 1,500 to 2,000 feet beneath the earth's surface at the plant, to warrant the next major step forward. This will entail construction of the shaft and exploratory tunnels, so that *in situ* examination can be made to verify the soundness of the bedrock.

Hanford Operations

Two high-level waste storage tanks, similar in design to those recently completed at Savannah River, are under construction at Hanford (these tanks also were successfully stress relieved by heat treatment in the field).

At the Hanford B Plant, facilities were installed for removal of cesium from the Purex plant's acidic, high level waste stream, using phosphotungstic acid precipitation. Previously, cesium was removed only from neutralized, aged high-level wastes by use of an ion exchange procedure. Removal of cesium-137 (and strontium-90) allows shorter cooling times before these chemical processing plant wastes can be reduced (by evaporation) to salt cakes for continuing storage in the underground tanks.

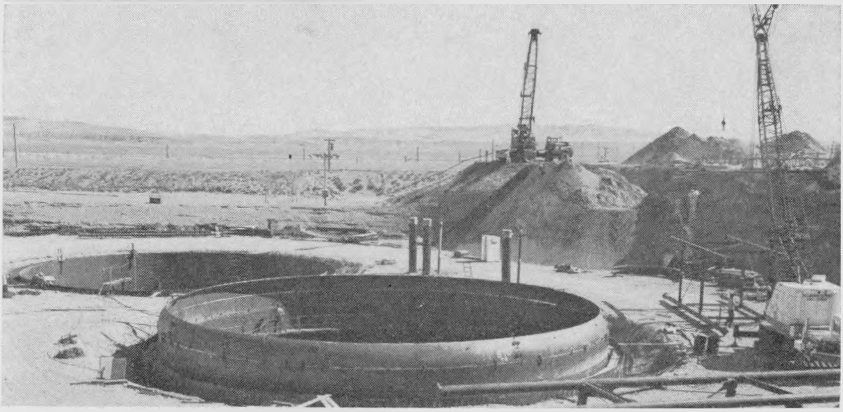
While the waste management activities at Hanford now routinely remove the cesium and strontium fractions from the high-level wastes, a cerium-144 fraction also is separated as requirements arise for this fission product. Some 25 million curies of cerium-144 and 28,000 curies of strontium-90 were transferred to the Pacific Northwest Laboratory to be used in other AEC programs.

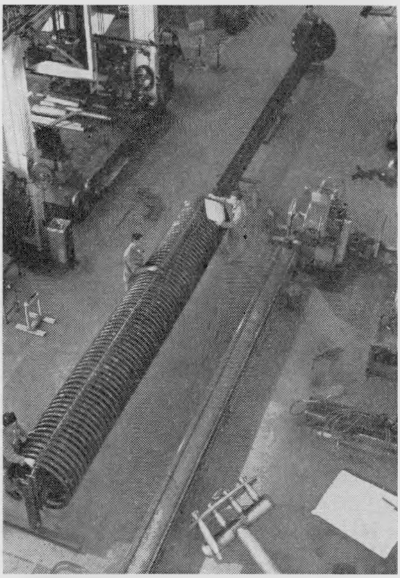
Two waste evaporators are currently operating in the deactivated Redox chemical processing plant for custom processing of contaminated wastes from on-site contractors. The evaporator "bottoms" (residue after evaporation) are stored in underground tanks. The evaporator operation, along with other efforts, is helping to reduce ground discharge of liquid wastes with low-levels of radioactivity.

Idaho Waste Calcining

At the National Reactor Testing Station, the fluid bed Waste Calciner Facility (WCF) completed a processing campaign that extended from August 1968 to June 1969.[12] During 1969, approximately 17,000 gallons of aluminum nitrate-type waste and 167,000 gallons of zirconium fluoride-type waste were reduced to approximately 2,830 cubic feet of granular calcine and stored in underground vaults. The feasibility and inherent safety of a concept for supplying the heat to the fluid bed by in-bed combustion of gas was proved, and work began to replace the liquid metal (sodium potassium (NaK) eutectic) heated coils in the calciner bed. In this new process, a hydrocarbon fuel is

[12] See p. 45, "Annual Report to Congress for 1968."





Two One-Million-Gallon underground waste-storage tanks (*above*) are under construction at the Hanford plant. The tanks, which will be covered over with earth, are constructed with a double wall designed to provide double containment of the wastes. The outer wall of steel has a reinforced-concrete outer liner. A 54-foot-long heating coil (at *left*) weighing 9,000 pounds was built in the pipe-fabrication shop at Hanford and installed in one of the one-million-gallon waste-storage tanks. There, steam is run through the two-inch-diameter piping in the coil, generating an estimated 5.6 million B.t.u. an hour. The heat evaporates liquid from the waste solution until the concentration of fission products increases to the point where the heat they produce is sufficient to cause self boiling of the waste solution.

fed into the preheated fluidized calciner bed, where it will burn (by autoignition) and provide heat for the calcination process.

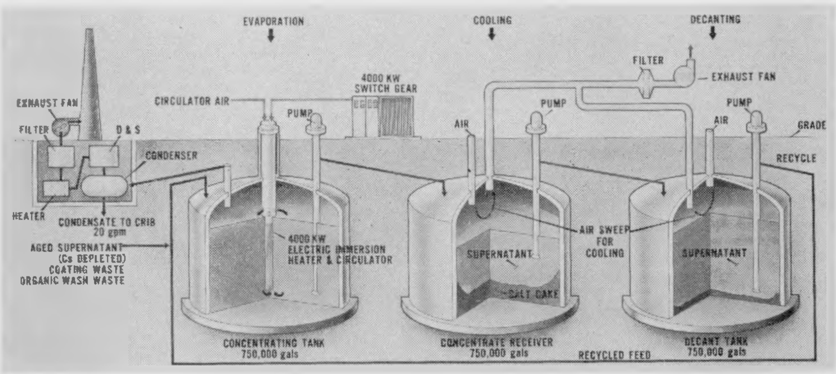
RADIOISOTOPE SALES

The Isotopes Development Center at Oak Ridge National Laboratory (ORNL) is the principal sales point for radioisotopes distributed by the AEC. During the 11 months ending November 30, 1969, a total of 2,308,346 curies of processed radioisotopes were distributed by ORNL. This represents a decrease of 32 percent over the same period in 1968. As specific radioisotopes become reasonably available from commercial producers, the AEC withdraws from their routine production. There were no withdrawals during 1969; however, since 1961, the AEC has withdrawn from the sale of 37 isotopes.[13]

Isotope Production in Power Reactors

A Pacific Northwest Laboratory (PNL) computer projection of isotope production by U.S. nuclear power reactors through 1990 has

[13] See p. 48 "Annual Report to Congress for 1968."



Non-Boiling Stored Liquid Wastes are being reduced in volume through evaporation at the Hanford Works using in-tank solidification. Evaporation eventually reduces the liquid to salt cakes reducing its mobility. An electric immersion heater is used to boil off water as steam. In the past 4 years, more than 30-million gallons of wastes have been evaporated. Aged wastes are received into the concentrating tank, which is equipped with a 4,000 kw. electric immersion heater contained in an airlift circulator. After boiling off water as steam which is condensed and discharged to ground, the concentrated liquor is pumped to receiving tanks where the concentrate is allowed to cool. Solids and dissolved salts that crystallize upon cooling settle in the receiver tanks. The remaining cooled supernatant is then decanted, mixed with fresh feed and recycled to the concentrating vessel.

provided the projected availability of 22 important and potentially useful radioactive and stable isotopes present in spent fuel from nuclear power reactors. These isotopes are valuable as heat and radiation sources, as rare elements, and as target isotopes for production of other isotopes. An experimental program was initiated at PNL to evaluate the quality of fission product rhodium and palladium obtained by the chemical reprocessing of commercial nuclear fuels. Preliminary results (with fuel from the Yankee reactor) indicate that palladium is of sufficiently low activity that it can probably be used safely for most commercial operations. Rhodium, which contains small amounts of the long-lived rhodium-102 (metastable) isotope, may also find use in special applications where this activity can be tolerated.

Pricing Actions

During 1969, the AEC increased its price for polonium-210 in order to recover full costs. Production cost increases resulted from a decrease in demand following cancellation of the SNAP-29 program to develop a polonium-210 fueled thermoelectric generator for space flight missions. Also, the AEC cancelled cesium-137 price increases which had previously been proposed in 1968.[14] Cancellation of the proposed increased prices resulted from a rapidly increasing sales rate for the radioisotope as well as a reduction in production and distribution costs resulting from process improvements.

Cobalt-60 Loan Program

In July 1969, the AEC offered to make available without charge a high specific activity grade of cobalt-60 for research and development on heat source applications of interest to AEC. The offer, for cobalt-60 of greater than 200 curies per gram specific activity, is to firms and organizations willing to undertake the research and development with their own funds. Title to the cobalt-60 would remain with the AEC. Participants in the program which is being administered by the AEC's Savannah River Operations Office, would be expected to provide their research and development results to the AEC generally for such use and dissemination as the AEC determined to be in the best interest of advancing this area of technology. At year's end, several firms had indicated an interest.

[14] See p. 48 "Annual Report to Congress for 1968."

Chapter 2

NUCLEAR MATERIALS SAFEGUARDS

MAINTAINING SAFEGUARDS

During 1969, the AEC continued emphasis on its program for safeguarding special nuclear material from diversions to unauthorized uses in the interest of common defense and security.[1] Progress was made to adapt the program so as to continue its effectiveness in the environment of the rapidly expanding nuclear power industry.

PROGRAMMATIC ACTIVITIES

Basic reporting and control systems for safeguarding nuclear material are now maintained on an operational status through a network of computers within the AEC. To make better use of the systems for both materials management and safeguards purposes, the maintenance and development of the systems are being integrated with the AEC's Management Information (computer) System at AEC Headquarters.

Safeguards Training School

The second course of the Argonne National Laboratory's Safeguards Training School[2] began on March 17, 1969. To provide a flexible capability for orienting new staff members and upgrading personnel assuming new responsibility, the second course was organized into three 3-week segments and a 1-week workshop so that individuals could participate in any, or all, to fit their particular need. A total of 53 individuals enrolled in one or more of these segments; 41 from Government and contractor organizations; four from U.S. industrial organizations; and eight from foreign organizations.

[1] See pp. 51–55, "Annual Report to Congress for 1967," pp. 51–58, "Annual Report to Congress for 1968," and pp. 111–121, "Fundamental Nuclear Energy Research—1968."
[2] See p. 54, "Annual Report to Congress for 1968."

Beginning on September 15, 1969, a third course condensed the same course material into eight weeks of intensive study. This course was attended by 25 individuals: 13 from foreign organizations; nine from Government and contractor organizations; and three from U.S. industrial organizations.

International Safeguards Activities

During the year, international safeguards activities continued in three major areas: (*a*) Direct application of safeguards under agreements for cooperation in civil uses of atomic energy or cooperation for mutual defense purposes; (*b*) cooperation with the International Atomic Energy Agency (IAEA) in safeguards; and (*c*) cooperation with the Euratom safeguards staff. The AEC continued direct application of safeguards in eight countries and 52 facility inspections were made in five of these countries during 1969. The inspections in these countries included four noteworthy events for the bilateral program:

(*1*) The first loading inspection of a power reactor (Tarapur reactor in India);

(*2*) The first inspection during unloading of fuel from a reactor (the submarine prototype PAT reactor in France);

(*3*) The first seals applied to a power reactor (NOK–1 reactor in Switzerland); and

(*4*) Inspection of the Lucens reactor in Switzerland following a radiation accident.

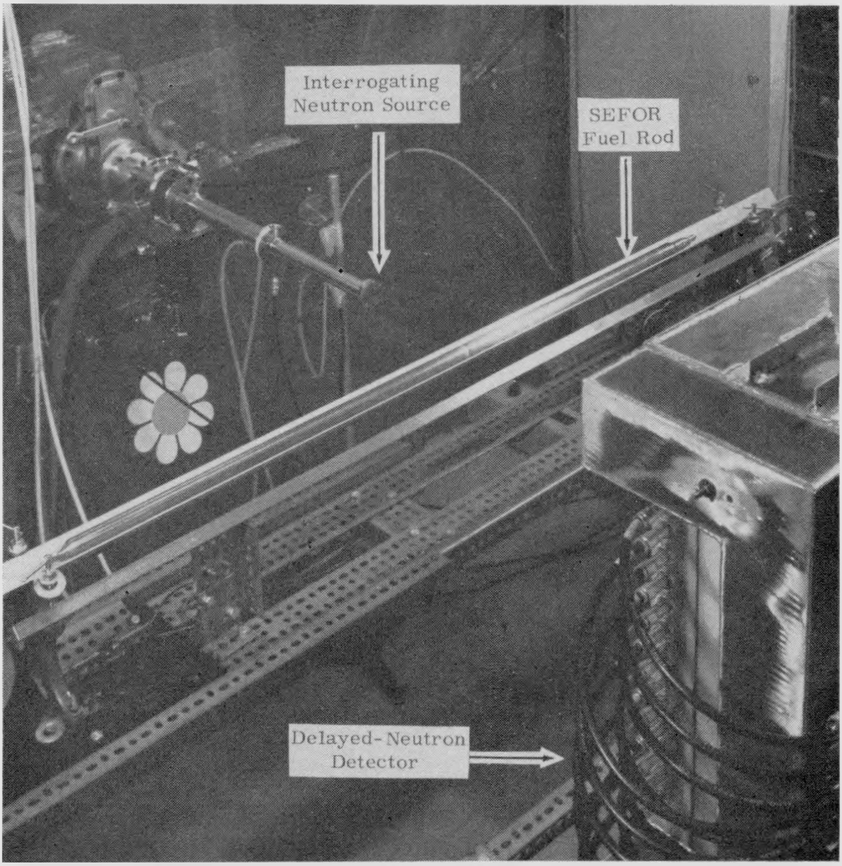
AEC and contractor staff members from the safeguards program participated in three IAEA panels on specific aspects of safeguards—in Vienna, Austria, during April and August, and in Tokyo during December. Meetings of the U.S.-Euratom Joint Technical Working Group on Safeguards were held in January, April, and September. These meetings were supplemented by informal exchanges on items of specific interest, by participation by the Euratom staff in the Safeguards Training School, and the October AEC safeguards symposium.

REGULATORY ACTIONS

In the regulatory area, the major safeguards effort of the AEC is directed toward those licensees who are authorized to possess and use more than 5,000 grams of contained uranium-233 and -235 (U^{233} and U^{235}) and/or plutonium in an unsealed form. At the end of 1969, there were 31 facilities operated by such licensees, including nuclear fuel processors, fabricators, and reprocessors. In addition, safeguards inspections are conducted at licensed power reactors.

Regulatory actions taken on behalf of the domestic safeguards program during 1969 included:

- The AEC reviewed safeguards programs of those licensees au-



The Fissile Material Content of various types of reactor fuels is being assayed nondestructively by delayed-neutron response techniques at the Los Alamos Scientific Laboratory. Photo *above* shows the experimental arrangement for determining the plutonium content of SEFOR fuel rods with the interrogating neutron source (produced by the Cockcroft-Walton accelerator at *left*) and a high-efficiency neutron detector to measure delayed neutrons produced in the SEFOR fuel rod (0.8″ o.d. x 49″ long). Data on samples of material assayed by nondestructive methods at Los Alamos have been very favorable (within 1 to 2 percent when compared directly with the conventional (destructive) chemical analysis of the samples at the AEC's New Brunswick Laboratory—the AEC's authority and final arbiter on chemical assay techniques and analysis.

thorized to possess and use more than 5,000 grams of contained U^{235}, U^{233} and/or plutonium in a form other than sealed sources and issued safeguards amendments to licenses to incorporate appropriate nuclear material controls as license conditions. The requirements pertain to the licensee's safeguards organization, facility operation, measurements and statistical controls, shipping and receiving, storage and internal transfers, inventory, records and reports, and management of materials control system.

- A new regulation was issued on April 9 [3] to require licensees to comply with specific requirements for safeguarding special nuclear material being transported. Also, the AEC issued for public comment, on June 10,[3] proposed amendments to 10 CFR Part 73 which would specify requirements applicable to special nuclear material in use and in storage.
- On June 10, the AEC adopted new nuclear material transfer and material status forms to achieve greater efficiency in the collection, analysis, and use of reported safeguards data on special nuclear material.
- Proposed amendments to 10 CFR Parts 40 and 150 were issued on September 12 which would require AEC and agreement State-licensees to also submit certain safeguards reports on normal uranium, depleted uranium, and thorium.
- The AEC issued for public comment, on April 25, a proposed amendment of 10 CFR Part 2 which would protect certain safeguards information from public disclosure in the interests of national defense.
- During 1969, 40 safeguards inspections were conducted at 38 licensed facilities to determine compliance with regulations.

RESEARCH AND DEVELOPMENT

A major objective of the AEC's safeguards research and development program is to develop more useful instruments and techniques for measuring the quantity of various fissionable isotopes in nuclear materials whether in partially or fully fabricated fuel, in scrap, or in "spent" (used) reactor fuel assemblies. Another major objective is the development of methods and procedures for preventing, as well as prompt detection of, the diversion of nuclear materials. These methods are expected to include physical protection as well as accountability procedures. By enabling quicker and more accurate accountability of these materials, the methods will provide a check against clandestine diversion of these strategic materials to nonpeaceful uses.

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[3] Date of publication in the *Federal Register*. See Appendix 5 for summaries of new regulations or amendments.

Safeguards Developments

A personnel doorway monitor to detect clandestine diversion of plutonium was designed and constructed by EG&G, Inc., for the AEC safeguards effort. After a public demonstration in October it was installed at the AEC's Rocky Flats Plant in Colorado.

Expressions of interest in a nuclear materials safeguards instrumentation program were solicited and received from companies manufacturing certain strategically significant fissionable materials. Demonstration experience, under plant operating conditions, is needed in connection with recent advances in nondestructive assay instrumentation.

Safeguards by conventional analytical chemistry have been strengthened by making available high purity samples of fissionable material. Some 500 samples of a plutonium metal primary chemical standard have been prepared by Los Alamos Scientific Laboratory and certified in collaboration with the National Bureau of Standards which will handle distribution to industrial and Government laboratories.

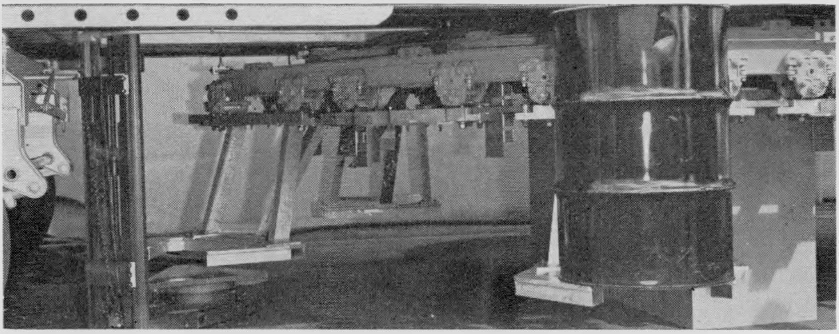
Systems Studies

Analytical studies were completed on specific fuel cycle processes and the results are providing useful guidance for improving safeguards techniques and implementing the nuclear materials safeguards control procedures. The studies included a facility for conversion of uranium hexafluoride (UF_6) to uranium dioxide (UO_2) or to uranium metal, and a facility for fabrication of low-enriched uranium fuel. Other studies are now being applied to additional facilities and include systematic characterization of unidentified process losses. The various possible sources of uncertainty are being given special attention.

Processes in AEC-owned plants are being studied by Pacific Northwest Laboratory. Studies have also been undertaken at specific privately owned plants. They are being carried out for the safeguards program by the National Bureau of Standards.

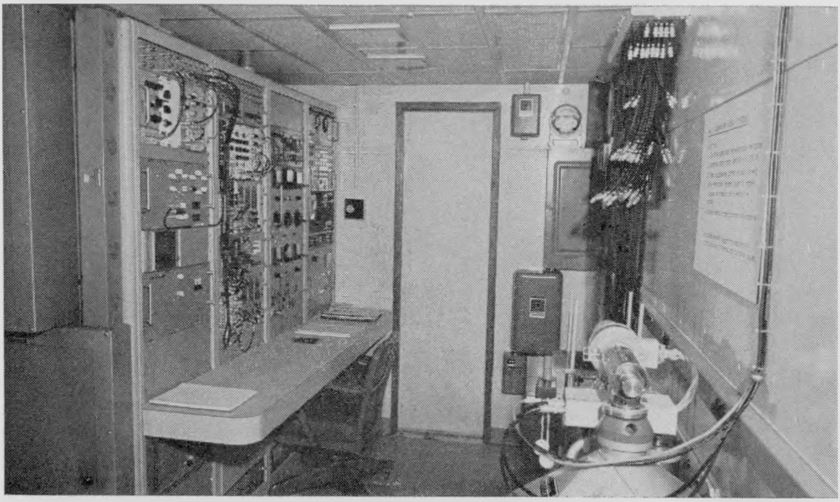
Technical Studies

The implementation of an effective nuclear safeguards and materials management system requires direct physical methods of detecting, identifying, and quantitatively analyzing fissionable materials in various practical configurations containing both fissionable and nonfissionable materials. The fundamental radiation characteristics ("signatures") of fissionable material are measured whenever existing data are inadequate for accurate assay applications. Such fundamental



A Mobile Nondestructive Assay Laboratory (MONAL), developed by the Los Alamos Scientific Laboratory, was first demonstrated at the AEC's 4-day symposium on nuclear safeguards research and development at Los Alamos, N. Mex., and La Jolla, Calif, during October. The symposium had representatives from 69 private companies, five universities, and eight foreign countries and international

organizations and included 29 exhibits, primarily of instrumentation and equipment that can be used for nondestructively assaying the fissionable content of plutonium- or uranium-bearing material. The MONAL is shown at *left* and the barrel-handling mechanism, located below the center of the van is shown in closeup view *above*. The conveyor moves the barrel into a shielded assay chamber (*behind* barrel) in which the fissionable material content is determined by the nondestructive neutron interrogation technique. Photo *below* is an interior view of the MONAL van with its control console and associated electronic equipment. The laboratory is now being used for practical in-plant and field demonstrations.



data include the detailed kinetics, yield, and energy characteristics of delayed fission neutrons, prompt fission neutrons and gamma rays, and fission-product gamma rays. These basic "signatures" are being applied in the development of practical methods and instruments for nondestructive assay of fissionable isotopes by both passive and active interrogation techniques.

Passive assay involves observation of naturally occurring neutron and gamma radiations from certain of the fissionable species, notably plutonium-239 and -240 (Pu^{239}, Pu^{240}) and uranium-235 (U^{235}). Active interrogation involves the use of an external source of highly penetrating neutrons or photons to induce fissions in the material under investigation; quantitative assay is then obtained from detailed observations of one or more types of emission following fission, notably delayed and prompt neutrons and gamma rays. Two separate active interrogation research and development projects, each to meet different measurement needs, are underway. One involves neutron activation being carried out for AEC by the Los Alamos Scientific Laboratory (LASL) and the other involves photon activation being carried out for AEC by the Gulf General Atomic Corp., San Diego, Calif.

LASL Neutron Activation Work

The newly developed neutron assay techniques have been applied at Los Alamos Scientific Laboratory in three major areas: (*a*) reactor fuels, (*b*) safeguards inventory samples and small test samples, and (*c*) fissionable scrap material. Examples of specific applications are listed below, together with an indication of the assay accuracy (using appropriate standards) achieved thus far.

(*1*) Fuels: Materials Testing Reactor (MTR) (0.5-1%); Molten Salt Reactor Experiment (MSRE) (~1%); Fast Flux Test Facility (FFTF) (1-1.5%); and Southwest Experimental Fast Oxide Reactor (SEFOR) (1-2.5%).

(*2*) Safeguards inventory samples (~1.5%).

(*3*) Fissionable scrap: Rover (nuclear propulsion rocket) dust (~5%); industrial process line scrap (~5%); and fire residues, conglomerates, and debris (*e.g.*, Rocky Flats) (5% or greater depending on sample size and composition).

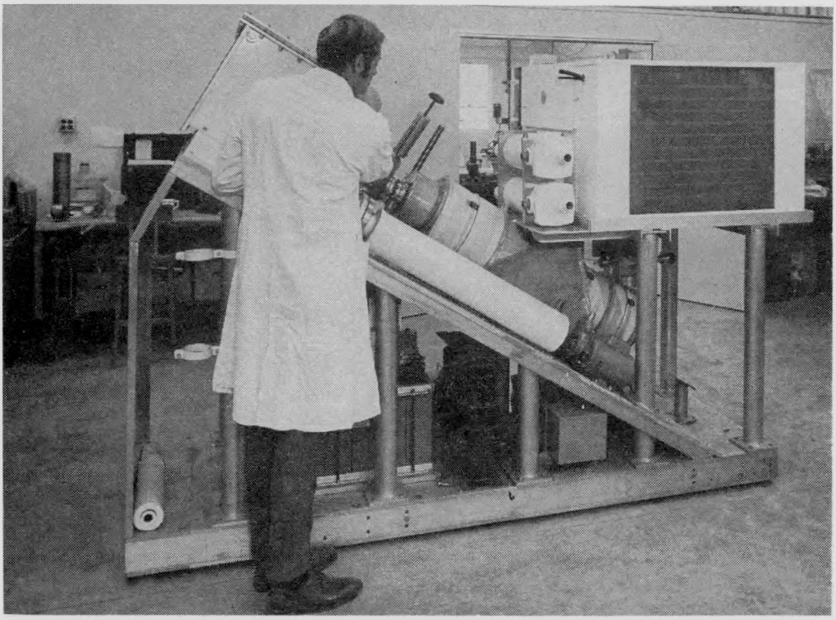
The experimental program in safeguards research and development at Los Alamos is paralleled by theoretical analysis and computer simulation of the response of various practical systems to active interrogation; these computations provide guidance for experiments and help to determine the precision of basic "signature" data required to achieve a specific accuracy in isotope assay applications.

The neutron assay methods promise extensive applications not only to safeguards inspection and surveillance, but also to nuclear materials management, accountability, quality and process control, economy, and safety in all types of nuclear facilities. Neutron interrogation methods are also being applied to inplant and onsite inspection of weapons-grade fissionable material in production and fabrication facilities to practical field problems of surveillance and verification of weapons integrity as well as integrity of components, mock-ups, and dummy systems for weapons development, diagnostics, and testing.

The new mobile nondestructive assay laboratory, first exhibited at the October safeguards symposium, is being used to demonstrate throughout the nuclear industry the practical inplant and field use of the newly developed nondestructive assay methods.

Photon Activation Work

Photon interrogation techniques have been applied at Gulf General Atomic in nondestructive assay of samples and results have been in



The Transportable Electron Accelerator shown in the illustration is being constructed for nuclear materials assay measurements. Associated assay equipment measures quantity of fission neutrons from material to be assayed when it is irradiated with gamma rays (bremsstrahlung) or high energy neutrons from the accelerator beam target. The accelerator and other associated equipment are being mounted in a truck trailer by Gulf General Atomic, San Diego, Calif.

satisfactory agreement with results from destructive measurements. Samples included uranium oxide and uranyl nitrate. Photon interrogation techniques are being applied to assay of a waste material—an abrasive grit containing significant quantities of enriched uranium oxide.

A new experimental cell is being used in conjunction with a linear accelerator for development of a narrow beam photon interrogation technique for nondestructive assay of the contents of 55-gallon drums.

Yields of some fundamental nuclear reactions have been measured because of their use in photon interrogation. Measurements included photon-fission reactions and "photon-in, neutron-out" reactions as functions of incident photon energy. Other measurements included energy spectra of radioactive decay gammas from the products of photon induced fission.

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Chapter 3

THE NUCLEAR DEFENSE EFFORT

NUCLEAR WEAPONS

The AEC, coordinating with the Department of Defense (DOD) which establishes nuclear weapons requirements in accordance with stated U.S. policies, conducts the required basic and applied research necessary for the development of nuclear weapons and devices, designs and develops test devices and nuclear weapons and their unique components (both nuclear and nonnuclear), and produces the DOD-required nuclear weapons which are essential to the maintenance and advancement of the United States nuclear defense capability.

In 1969, the AEC continued: (*a*) The design and development, testing, and production of both nuclear weapons and their components programed to meet military requirements as approved by the President; (*b*) the development of nuclear test devices to investigate design concepts, effects, and the development of improved data acquisition systems and diagnostic instrumentation techniques for the underground test program; (*c*) the maintenance of the atmospheric test readiness capability in accord with assurances given to the Senate prior to ratification of the limited nuclear test ban treaty;[1] (*d*) its participation with the DOD in the nuclear detonation detection (Vela) research and development program; and (*e*) its cooperation with other countries or regional organizations (NATO) in mutual defense agreements for the exchange of specific nuclear weapons information.[2]

[1] The four presidentially affirmed safeguards (first affirmed in 1963 by President Kennedy as U.S. national policy) are: (*1*) Continuation of an aggressive underground nuclear weapons test program; (*2*) maintenance of a progressive laboratory program; (*3*) a readiness capability to resume atmospheric tests if they should be essential to national security or if the treaty should be abrogated by others; and (*4*) the improvement of our capability, within feasible and practical limits, to monitor the terms of the treaty and to detect violations.

[2] Twelve mutual defense agreements for cooperation are currently in effect (see Appendix 6).

WEAPONS RESEARCH AND DEVELOPMENT

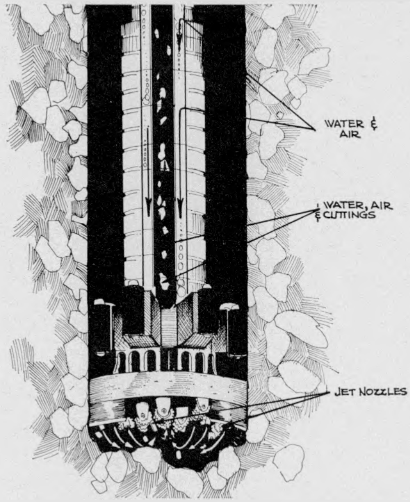
Nuclear weapons research and development in 1969 included studies of new weapon concepts, the evaluation and testing of their feasibility, detailed design of weapons and testing of components, and development of new and advanced materials and processes. In addition, a broad-based fundamental research program was conducted including, for example, investigations in nuclear and atomic physics, solid state physics, hydrodynamics, general and physical chemistry, metallurgy, mathematics, and computational code development. Such activities are essential to: (*a*) Meet DOD's requirements for weapons, (*b*) advance the level of weapons technology, and (*c*) maintain the laboratories in a viable state as required by the assurances given prior to the Senate's 1963 ratification of the limited nuclear test ban treaty. These research and development activities were conducted primarily at the three major weapons laboratories: Los Alamos Scientific Laboratory (LASL), Los Alamos, N. Mex.; Lawrence Radiation Laboratory (LRL), Livermore, Calif.; and the Sandia Laboratories at Albuquerque, N. Mex., and Livermore. Nuclear design activities are conducted at the LASL and LRL facilities, and nonnuclear engineering and development activities are conducted at the Sandia Laboratories.

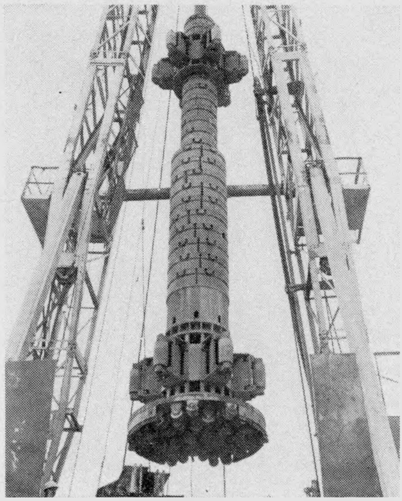
Research and development, directed to improving the simulation of effects and environments within the laboratory, was continued. New laboratory simulators of weapon environments and effects were used to accelerate the development of new weapons materials and components, and to improve the quality and reliability of experiments conducted in underground tests.

Underground nuclear weapons development tests continued in 1969. These included tests of experimental devices, devices being weaponized, and proof tests of weapons. Instrumentation systems of increased capability and complexity were employed in conjunction with the tests. Nuclear effects tests required in support of development programs were also conducted. AEC technical and logistical support was provided for those nuclear events required by the DOD. The drilling of large-diameter holes for the underground detonations continued to provide "spinoff" innovations that will benefit the drilling industry.

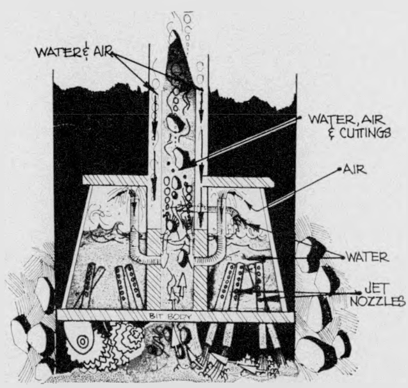
WEAPONS PRODUCTION

The 1969 weapons production effort was directed primarily toward producing weapons for existing tactical and strategic systems with no new weapon system being introduced into the stockpile.





A New Technique for Removing Cuttings and cleaning the bottom of drill holes has been devised by the Reynolds Electric & Engineering Co., Inc. (REECo), the AEC's support contractor at the Nevada Test Site. The innovation is another useful "spinoff" for the drilling industry from the underground nuclear weapons test program, and may revolutionize water well drilling and the drilling of mining-exploration holes. The new technique, called "Dual Circulation," requires dual concentric drill pipe and utilizes both air and water as a circulating medium. The two media are simultaneously pumped down the dual drill pipe annulus and into the bit body. Gravity separation occurs at that point, the water falling to the bottom of the bit and being forced through conventional jet nozzles to impinge on the hole bottom, and the air rising to the top of the bit and being forced through converging jets into the inner drill pipe string as shown in drawing at *left above.* This aerates the fluid column in the inner string and induces circulation of the water and bit cuttings to the surface where the cuttings are removed and the water reused. Drawing at *left* shows concept of the drill-bit body; photo *above right* is of a drill assembly with its donut-shaped weights which provide crushing force for the drill bit. In rotary drilling, efficiency is a function of bottom cleaning and cuttings removal. These present no problem in drilling conventional-sized holes. However, in "big" holes (more than 36 in. diameter), prior to the advent of the dual circulation method, one factor was usually accomplished only at the expense of the other. The results from dual circulation drilling on the Nevada Test Site have been excellent. A recently completed 10-foot diameter hole had an average daily penetration of 62-feet and, within one 24-hour period, drilled 100 feet. This hole was drilled in moderately consolidated alluvium containing a high percentage of gravel and boulders. The average penetration rate was 5.47 feet an hour. Maximum penetration rates of 10 feet per hour were achieved in short intervals.



Stockpile Improvement

In addition to producing weapons, activities included the improvement of existing weapons through modification programs, quality assurance testing and evaluation of weapon reliability, and the providing of training weapons and materials. The retirement and disposal of obsolete weapons continued with emphasis on the maximum reuse of components and materials.

The continuing emphasis on meeting weapons production requirements at minimum cost has resulted in the startup of a production facility at the Savannah River plant to reclaim components from stockpile which will reduce the requirement for new production of these items.

In addition to specific cost-savings actions, the management of the weapons program stressed economy with special attention to the salvage and use of especially designed weapons material for maintenance and training purposes.

Production Facilities Expansion

The current estimate for the construction and equipment expansion and modernization of production facilities for new weapons systems requested by the DOD is $315 million.[3] This program is expected to be completed in 1972.

Rocky Flats Plant Fire

A major fire on May 11, 1969, in two buildings (interconnected No. 776/777) of the AEC's Rocky Flats plant near Denver, Colo., reduced the plant's production capability. The fire occurred during nonworking hours on a Sunday afternoon and was fought entirely by personnel of the operating contractor, the Dow Chemical Co. There were no physical injuries, and only one employee, a fireman, received radiation exposure slightly above radiation protection guide levels. He was successfully treated and returned to duty.

The present estimate of the financial loss for the damage to buildings and equipment, including the cost of decontamination, is about $45 million. The estimate does not include the cost of the plutonium recovery—more than 99 percent of the plutonium in the building has been retrieved and eventually will be reused. The small balance is combined with other fire debris and will be handled routinely as is other waste material.

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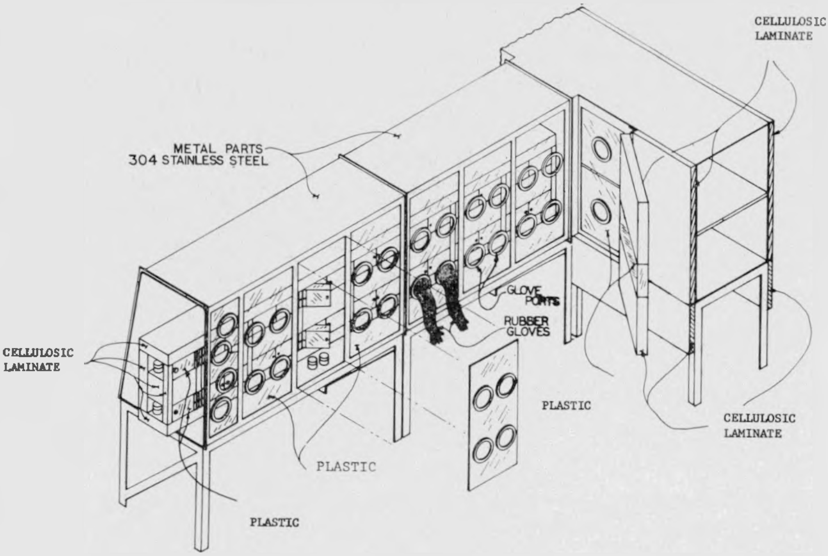
[3] See p. 62, "Annual Report to Congress for 1968."



Fire, Starting in a Glovebox, caused an estimated $45 million loss at the AEC's Rocky Flats Plant in Colorado during May. The plant fabricates plutonium components and because of the toxicity of plutonium, all operations are conducted in gloveboxes. The loss estimate includes the cost of the extensive decontamination work necessary since, in addition to the actual fire and smoke damage, the buildings and equipment were heavily contaminated with airborne plutonium. There is no evidence that plutonium was carried beyond the plant boundaries. Photo at *left* shows a decontamination crew atop a glovebox. The available evidence indicates that the fire originated on the lower shelf of the storage cabinet in a glovebox (diagramed *above*) in which plutonium briquettes (discs 3-inches in diameter and 1 inch thick of either pressed scrap metal or lathe turnings) and some loose scrap metal were stored in uncovered cans in the storage cabinet (*left* in drawing). The exact cause of ignition is unknown; however, plutonium in the form of chips or lathe turnings is a pyrophoric material. The heat from the burning plutonium metal evidently caused the cellulosic laminate and plastic storage cabinet to char and generate flammable gases which could have been ignited by burning plutonium. The heat of the burning gases could ignite other briquettes and initiate a slow burning of the storage cabinet materials, particularly in the cracks between the joined sections of the cellulosic materials. The fire apparently spread through the interconnected conveyor system used for the extensive glovebox complex.

Rocky Flats is the primary facility in the AEC weapons production complex for fabrication of plutonium weapons parts. Several critical items of equipment were destroyed, damaged, or contaminated with radioactive material. All of this process equipment is contained in ventilated and shielded enclosures (gloveboxes) that are interconnected by conveyor systems.

Cleanup activities began on May 15, 1969. The estimated time to return the buildings to the same condition as before the fire ranged from 1 month for the lightly damaged areas to perhaps as long as 3 years for some selected and less critical parts of the most heavily damaged and heavily contaminated portion of the buildings.

The plan for recovery of capabilities is proceeding in two phases. The first phase is aimed at achieving an interim capability to support process engineering and limited production to enable the AEC to meet initial delivery schedules for the Minuteman and Poseidon warheads. This is being done by expanding a small existing development glovebox line, not damaged by the fire, in the south portion of buildings 776/777.

The second phase is aimed at recovery of full capability for quantity production. This is being accomplished by building a 24,000-square foot, two-story addition to the adjacent building 707 which was not damaged by the fire. This addition will support the limited production capacity of the development line in buildings 776/777.

To obtain the full capacity required to meet the current approved weapons production schedules, a program to decontaminate, cleanup, and recover operational status (on a temporary basis) of the south production glovebox line in buildings 776/777 is continuing. Decontamination and cleanup are also proceeding in the remaining areas of the buildings.

UNDERGROUND NUCLEAR TESTS

The AEC continued, in 1969, to conduct a comprehensive underground nuclear test program at the Nevada Test Site (NTS), and the supplemental areas, as called for in the first safeguard associated with the limited nuclear test ban treaty. As a result of this continuing test program, a capability to support a varied range of AEC and DOD underground nuclear tests has been developed, maintained, and improved. Objectives of individual nuclear tests during 1969 included the development of improved nuclear weapons, furtherance of the Plowshare program (see Chapter 11), and investigations of the effects of nuclear detonations on strategic missiles and their components.

Bowline-Mandrel Test Series

The 1969 test series consisted of parts of two series which are conducted on a fiscal year basis (July 1 through June 30 each year). The Bowline series ended on June 30, 1969. The Mandrel series began on July 1, 1969, and will continue through June 30, 1970. The planned tests are categorized in three broad groups: (*a*) Weapons-related (including device development and DOD nuclear effects tests); (*b*) joint AEC–DOD tests for research and development purposes on the improvement of detection methods and systems (Vela Uniform); and (*c*) Plowshare (peaceful uses of nuclear explosives) experiments (see chapter 11—"The Plowshare Program"). All planned nuclear tests are thoroughly reviewed to assure that they can be conducted in accordance with established AEC procedures for public safety and consistent with U.S. obligations under the limited nuclear test ban treaty.

Tests Summary

Eleven defense-related underground tests were publicly announced in 1969 under the Bowline series (ending June 30, 1969); 16 defense-related tests have been publicly announced under the Mandrel series. (See appendix 4 for names, dates, and yields of announced tests in 1969.) One of the 16 tests conducted under the Mandrel series was a higher yield test on Pahute Mesa of the NTS—the Jorum test event on September 16 had a yield in the intermediate (200 kiloton (kt.) to 1 megaton (mt.)) yield category. The seismic aftershock activity observed following Jorum was less than that observed following the Benham test of December 19, 1968.[4]

Amchitka Underground Nuclear Test

The AEC successfully conducted an underground nuclear calibration test at Amchitka Island, Alaska, on October 2. The detonation, called Milrow, employed a device of known explosive power—the equivalent of about 1 megaton of TNT. Tests of similar yield had previously been safely conducted at the Nevada Test Site. The Milrow device was detonated at a point 4,000 feet below the surface.

The Milrow test announcements resulted in an extremely vocal public reaction, much greater than has been encountered in the announcements of high yield tests at the Nevada Test Site. However, the test was carried out because of its extreme importance to national

[4] See pp. 62–63, "Annual Report to Congress for 1968."

defense. Through an effective public information program and an extensive program of providing immediate replies to individual queries from the public, the public was assured of the all-encompassing safety program which is mandatory with all nuclear tests.

On October 3, the AEC announced that the Amchitka Island test went as predicted. The test registered 6.5 on the Richter scale, which is precisely what had been forecast in an initial announcement of the test on September 24. Also, as forecast, there were no damaging earthquakes. It was necessary for the technicians to turn up the gain on their seismic detection instruments in order to be able to read the aftershock activity.

Temporary buildings at ground zero showed external evidence of damage but were still standing. Careful examination of the extensive instrumentation indicated no radioactivity escaped either to the atmosphere or to the sea.

No significant water wave activity was recorded on any of the instrumentation. Preliminary observations made within 0.6 mile from ground zero indicated no apparent ecological effects. A few fish in ponds located 0.4 and 0.8 of a mile from ground zero were killed by underwater overpressures. None of the sea otters who were in the experimental group penned nearest the shot—at a distance of 4,500 feet from ground zero—appeared to be injured. One sea otter, located in a floating pen 9,150 feet from ground zero was subsequently found dead—apparently from handling stresses since an autopsy showed no evidence of pressure injury. The AEC, at the request of the State of Alaska and in conjunction with the U.S. Department of Interior's Bureau of Sports Fisheries and Wildlife had, during 1968 and 1969, relocated [5] some 600 otters to other islands, the State of Washington, and the Province of British Columbia in an attempt to establish new colonies since it appeared the Amchitka food supply was inadequate to support the growing otter population.

Data from Milrow will be extensively analyzed and the knowledge gained from these analyses will be carefully studied before any determination is made regarding further testing on the island.

Central Nevada Test Area Status

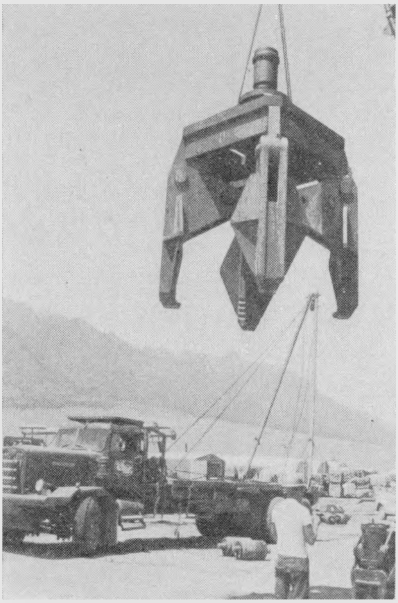
The Central Nevada supplemental test area, about 175 miles northwest of Las Vegas, has now reached a near-operational status. An AEC-owned, 250-bed camp facility was moved to the site in early 1969 and is being contractor-operated. Major supporting facilities are es-

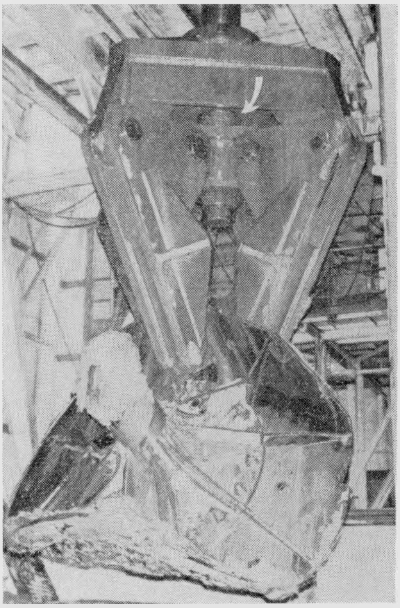
[5] See pp. 66–67, "Annual Report to Congress for 1968."

sentially complete with construction of technical facilities still in progress. Two emplacement holes have been drilled—one is currently being cased, the other will be cased at a later date.

ATMOSPHERIC TEST READINESS CAPABILITY

In 1969, the AEC continued to maintain the atmospheric test readiness capability which was attained on January 1, 1965. This test readiness gives the United States the capability to resume testing, when authorized, in a minimum reaction time in the environments (atmosphere, space, and underwater), prohibited by the limited nuclear test ban treaty. Such an authorization would not be forthcoming un-





A Mechanical Grab "Fishing" Tool, conceived and designed by the AEC's Nevada Operations Office staff, has taken some of the tedium out of recovering "lost" equipment from the deep holes drilled for underground nuclear tests. The tool was fabricated for the AEC by Drilco, Inc. (Odessa, Tex.). Weighing 53,000 pounds, the grab is shown being picked up (*left*) with a crane before being placed into position under the drill rig floor to be lowered into a 120-inch diameter hole. The tool is lowered into the hole on drill pipe and is closed by the screw (*arrow* in *right* photo) being rotated by the drill pipe at the surface with the drill rig. The grab has been successful in removing a 110-inch tool (*right* photo) that was lost in a hole drilled in Central Nevada. Recovery of the "junked tool" from the hole was the turning point toward success in an extremely difficult "fishing" operation.

less the treaty was abrogated by others or the United States exercised the right of withdrawal which the treaty provides. This capability is the result of presidential reassurances given to the Senate in 1963, prior to ratification of the treaty.

Summary of Readiness

The test readiness capability includes the maintenance of necessary ground facilities, aircraft, instruments and instrumentation systems, and personnel capabilities, in conjunction with the DOD, both in the continental United States and overseas (Hawaiian Islands and Johnston Island) for launching and acquiring data from an atmospheric test initiated on short notice. The airdrop, missile launch, and diagnostic capabilities have been maintained in readiness through the updating of systems, facilities, and plans as new data are acquired through laboratory techniques or from the continuing underground test program. Nonnuclear readiness exercises, based in the continental United States and overseas, have been conducted to insure technical proficiency of air crews and scientific personnel as well as to test and exercise the aircraft and instrumentation systems. One continental U.S.-based exercise was conducted in 1969.

Diagnostic Aircraft Utilization

Established AEC policy permits the use of the diagnostic aircraft (three NC–135 aircraft modified for instrumentation purposes with one assigned to each laboratory— LASL, LRL, and Sandia), for other appropriate scientific tasks on a noninterference basis with the readiness program and within budgetary limitations.

One of the aircraft was used in January 1969 to conduct an airglow latitude survey mission off Puerto Rico. Two of the aircraft were used in March to gather data from nonnuclear device airdrops conducted at the Tonopah test range, Nevada. In March, one of the aircraft flew 12 missions in Alaska in support of an AEC–DOD rocket launch program. One diagnostic aircraft flew to Sydney, Australia, in May for a series of missions to acquire data to determine the location and character of continuous conjugate [6] photoelectron airglow enhancement in the Southern Hemisphere. This data will equate to, and be comparable with, similar data recorded off the U.S. Atlantic coast. One aircraft was based in Buenos Aires, Argentina during August, to gather additional data on airglow and cosmic rays. The NC–135 aircraft were

[6] Observations made in the Northern and Southern Hemispheres at the same magnetic field points.

also used for scientific measurements during the Milrow and Jorum events (see Appendix 4).

VELA PROGRAM ACTIVITIES

The Vela program is a joint AEC–DOD research and development program conducted to obtain data to improve the U.S. capability to detect, identify, and locate nuclear detonations conducted in various media, in accordance with Safeguard 4 (see footnote 1) of the limited nuclear test ban treaty assurances. The joint effort is supervised by the Advanced Research Projects Agency (ARPA) of the DOD. The Vela program has three subprograms: (*a*) Detection of underground nuclear explosions; (*b*) detection, by satellite-based instrumentation systems, of nuclear explosions in space and in the atmosphere; and (*c*) detection of nuclear explosions in space by ground-based systems.

Vela Uniform

Five underground nuclear experiments[7] have been conducted in prior years for the Vela Uniform underground detection subprogram; none were done during 1969. Measurements of ground shock and other effects, and the operation of seismic recording stations to record seismic data, continued in 1969 at the NTS in conjunction with the continuing underground test series.

Operations at the Salmon-Sterling Site

The first of a planned series of three nonnuclear gas explosions to generate seismic data simulating a nuclear explosion was conducted by the DOD in February 1969 at the Hattiesburg, Miss., site. The data has been analyzed and compared with data previously recorded from both Salmon and Sterling. The site has been placed in a standby status pending ARPA's negotiations with AEC and the Defense Atomic Support Agency (DASA) prior to proceeding with the second explosion of the series, possibly during 1970.

Vela Satellite

The joint AEC–DOD satellite-based detection program continued in 1969 with the fifth launching of AEC-instrumented twin satellites

[7] Shoal in October 1963 near Fallon, Nev.; Salmon in October 1964 near Hattiesburg, Miss.; Long Shot in October 1965 on Amchitka Island; Sterling in December 1966 in the Salmon cavity; and Scroll in April 1968 at the Nevada Test Site (NTS).

into orbit. The Vela V launch was conducted on May 23 1969, from Cape Kennedy and used a Titan III-C booster.

Detection instrumentation is performing about as planned. The 1969 spacecrafts are earth-oriented and in near-circular orbits, with radii of about 65,000 nautical miles, comparable to the previous eight spacecraft. The four earlier launches of twin spacecraft occurred in 1963, 1964, 1965, and 1967. Improved detector systems for neutrons, gamma rays, and X-rays were incorporated in the latest spacecraft. Other instruments gather data on background radiations and other solar-terrestrial relationships; the two Vela V satellites recorded the appearance in early July of an intense X-ray source in space which subsequently decayed gradually to a level that could not be observed.

The final Vela launch, using spacecraft and instrumentation similar to those of Vela V, is planned for the spring of 1970.

Chapter 4

NAVAL PROPULSION REACTORS

NUCLEAR FLEET

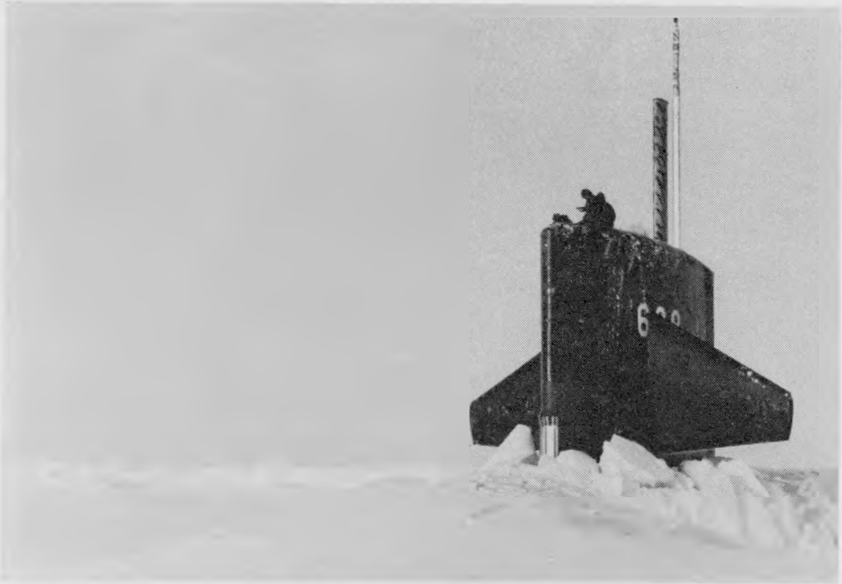
The naval propulsion reactors program is a joint program of the AEC and the Department of the Navy which has as its objective the design and development of improved nuclear propulsion plants and reactor cores for installation in Navy ships ranging in size from small submarines to large combatant surface ships.

Operating Nuclear Ships

Congress has authorized 110 nuclear-powered submarines including 41 of the Polaris missile-launching type and one deep submergence research vehicle, as well as nine nuclear-powered surface ships. Of these, 86 nuclear-powered submarines, one deep submergence research vehicle, and four nuclear-powered surface ships—the aircraft carrier *Enterprise*, the guided-missile cruiser *Long Beach*, and the guided-missile frigates *Bainbridge* and *Truxtun*—are now in operation and have steamed a cumulative distance of over 14.5 million miles.

During 1969, the *Enterprise* completed her fourth Vietnam combat deployment and returned to the U.S. in late summer for refueling and overhaul, having steamed over one-half million miles since commissioning in 1961; the *Long Beach* returned to the Pacific in late summer for her third Vietnam combat deployment; the *Bainbridge* completed her third Vietnam deployment and returned to operate with the First Fleet; and the *Truxtun* operated with the First Fleet before departing, in the fall, for her second Vietnam combat deployment. The operation of these nuclear-powered surface ships continues to demonstrate, under actual combat conditions, the significant advantages of nuclear propulsion in surface warships.

In August 1969, the world's first nuclear-powered deep submergence research vehicle, the NR–1, successfully completed her initial sea

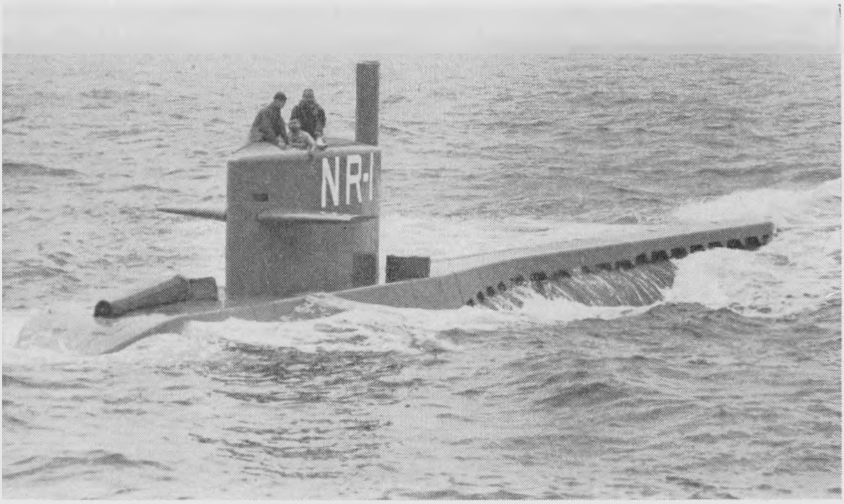


"*Alone in Remotest Waters . . .*," a quote from Herman Melville, author of "*Moby Dick*," hangs in the crew's mess of the nuclear-powered attack submarine USS *Whale* (SSN–638). The quote was most appropriate on April 6, 1969, as the *Whale* (photo *above*) surfaced at the North Pole, 60 years to the day and hour after Admiral Robert E. Peary and Matthew Henson reached the pole in 1909. One of the newest of the Sturgeon class attack submarines, the *Whale* surfaced while conducting an exercise designed to demonstrate under-ice capabilities. The first polar surfacing by a nuclear-powered submarine was made by the USS *Skate* on March 17, 1959. In photo *below*, a U.S. Navy aircraft flies by the USS *Swordfish* (SSN–579) during operations in the South China Sea. At present, 86 nuclear-powered submarines, one deep submergence research vehicle and four nuclear-powered surface ships are in operation and continue to demonstrate the significant advantages of nuclear power for the propulsion of Navy ships.

trials. This vehicle, which is manned by a crew of five and two scientists, provides the capability of exploring essentially all of the Continental Shelf, an area that appears to contain most of the accessible wealth in mineral and food resources in the seas. It is also capable of engaging in a variety of other underseas research projects such as charting ocean currents, studying water temperature, and gathering other oceanographic data of military, commercial, and scientific value. The capability of the NR–1 is greater than that of any other deep submergence research vehicle developed or planned to date because of the vastly increased endurance afforded by nuclear power.

New Surface Ships Planned

During 1969, construction proceeded on two guided-missile nuclear frigates (DLGN 36 and 37). These new frigates, along with four nuclear-powered guided-missile frigates of a new class, will become part of two all-nuclear attack carrier task groups which were approved by the President in 1968. The decision to complete these task groups represents a major step in the application of nuclear power to surface



The Navy's First nuclear-powered oceanographic research submarine, the NR–1, was launched at Groton, Conn., on January 25, 1969, and successfully completed her initial sea trials during August. Manned by a crew of five plus two scientists, the NR–1's endurance for underwater exploration is limited only by the amount of provisions carried aboard for the personnel. The new submarine will be used to study and map the ocean bottom, and collect temperature and current data of military, scientific, and commercial interest.

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warships. Congress authorized construction of the first of this new class of guided-missile frigates (the DLGN 38) in 1969.

A high level of effort continued during 1969 on the development of a two-reactor nuclear propulsion plant for the Navy's second nuclear-powered aircraft carrier, the *Nimitz* (CVAN 68), the keel of which was laid in June 1968. Her two reactors are the highest-powered reactors under development in the naval program, each producing about as much power as four of the *Enterprise* reactors. With these two reactors, the *Nimitz* will be able to operate for about 13 years without refueling. A second *Nimitz*-class, nuclear-powered aircraft carrier was authorized by Congress in 1969, and a third is planned by the Department of Defense for authorization in future shipbuilding programs, which would make a total of three new nuclear aircraft carriers in addition to the *Enterprise*.

New Submarines Planned

Work continued in 1969 on the development of two new design nuclear attack submarines—the electric drive submarine, and the high-speed submarine. The electric drive submarine is being designed to be significantly quieter than any other nuclear submarine existing or planned; it was approved by Congress in the fiscal year 1968 shipbuilding program. The objective of the high-speed submarine, on the other hand, is the development of a submarine capable of higher operating speed than any other U.S. submarine developed to date. The fiscal year 1970 shipbuilding program authorized by Congress includes construction of the first three of these new design, high-speed submarines.

Throughout 1969 the AEC continued to emphasize research and development work on advanced naval reactor cores of greater reliability, higher power, and longer life. The first core in the *Nautilus* propelled the ship for 62,000 miles while cores now being installed in nuclear submarines will last for more than 10 years of normal operation and propel the ship for approximately 400,000 miles.

Chapter 5

REACTOR DEVELOPMENT AND TECHNOLOGY

GROWTH OF NUCLEAR POWER

Three new nuclear power stations became operational in 1969, and electric utilities in Alabama, New Jersey, North Carolina, and Ohio contracted for seven more nuclear reactors, making a yearend total of 97 central station nuclear power reactors with a net capacity of 72,789 Mwe. (megawatts of electricity) under contract, under construction, or operable in the United States.

New Plants in Operation

Beginning operation in 1969 were three nuclear plants with a combined output of 1,435 Mwe.

In May, the 515-Mwe., General Electric-built Oyster Creek (N.J.), station of the Jersey Central Power & Light Co. began operation. The Nine-Mile Point Nuclear Station (N.Y.) added 500 Mwe. to the Niagara Mohawk Corp.'s power grid after the General Electric-built boiling water reactor was started up in September. The 27th anniversary date of the birth of nuclear fission (the "Fermi Pile," University of Chicago, December 2, 1942), was marked by the first commercial operation of the R. E. Ginna Nuclear Power Plant (N.Y.); the 420-Mwe. Westinghouse pressurized water reactor plant is owned by Rochester Gas & Electric Co.

At the year's end, the Commonwealth Edison's 809-Mwe. Dresden unit 2 in Illinois was being fueled. (Criticality was achieved 1/7/70).

Nuclear Plants Ordered in 1969

In May, the Alabama Power Co. announced that it would build an 820-Mwe. nuclear power station for 1975 operation. The plant is to be located on the banks of the Chattahoochee River near Dothan, Ala., with Westinghouse Electric Corp. (Pittsburgh, Pa.), providing the nuclear reactor and the turbine generator. The Bechtel Corp. (San Francisco) and Southern Services, Inc., like Alabama Power, an affiliate of the Southern Co., will design the plant.

In August, the Public Service Electric & Gas Co. (a New Jersey utility) announced a contract award to the General Electric Co. (Schenectady, N.Y.), for two 1,100-Mwe. nuclear reactors to be used in generating units scheduled for 1975 and 1977 operation on Newbold Island, 6 miles from Trenton, N.J. Public Service is one of four utilities now building the two-unit Salem Nuclear Generating Station at Salem, N.J., scheduled for operation in 1972 and 1973; the utility is also a participant in the Peach Bottom (Pa.) units 2 and 3 projects.

In September, the Cincinnati Gas & Electric Co. (CG&E), the Columbus & Southern Ohio Electric Co., and the Dayton Power & Light Co., announced award of a contract to General Electric to supply the nuclear steam supply system for an 840-Mwe. nuclear powerplant. The plant, to be located near Moscow, Ohio, is scheduled for completion in 1975. It has been named the William H. Zimmer Nuclear Power Station.

In November, Duke Power Co. (Charlotte, N.C.), announced plans to install two more nuclear reactors at an undesignated site. The reactors, with a rating of 1,100 Mwe. each, are to be provided by Westinghouse Electric Corp., and are scheduled for initial operation in 1977 and 1979.

In December, Jersey Central Power & Light Co. announced the purchase of a 1,100-Mwe. reactor from Combustion Engineering Co. It is scheduled for operation in 1976 at the Toms River, N.J., site of Jersey Central's Oyster Creek Nuclear Power Plant, Unit 1. Burns & Roe will be the architect-engineer and construction is scheduled to start in mid-1971.

Between now and the end of 1975, some 75 nuclear electric stations with a combined generating capacity of more than 60,000 Mwe. are scheduled for startup, and by 1980, the total nuclear electric capacity in the United States should be about 150,000 Mwe.

BREEDER REACTOR DEVELOPMENT

Utility commitments for nuclear power have been almost exclusively for light water reactor plants. Today's reactors are the result of more than 2 decades of AEC- and industry-sponsored research and development on pressurized and boiling water reactor systems. The AEC is continuing its strong interest in water reactors because their timely construction and reliable operation are essential to the power supply of the country. There also has been strong AEC and utility interest in the development of high temperature gas-cooled reactors (HTGR); a prototype is under construction. However, these reactors do not utilize available resources as efficiently as breeder reactors, so to more fully utilize the energy available in the Nation's nuclear resources the AEC's civilian power reactor development effort is now concentrated on achieving safe, reliable, and economic breeder reactors.

During power operation, breeder reactors produce more fissionable material than they consume. This is done by placing fertile materials in the reactor to absorb neutrons which are in excess of those needed for maintaining the fissioning process. This absorption converts the fertile material to material which is itself fissionable.[1] This process is called breeding.

Reactors can be designed to enhance this breeding process, and various types of coolant can be used to remove heat from the fuel and transfer it to the electric generating system. The AEC is examining coolants of liquid metal, gas, water, and molten salts. In the civilian nuclear reactor development program, the highest priority has been given by the AEC to the reactor concept using liquid metal as a coolant, the liquid metal fast breeder reactor (LMFBR).

LMFBR PROGRAM

During 1969, design studies were continued on 1,000-Mwe. LMFBR plants, and the AEC entered into the project definition phase of its plan to construct 300 to 500-Mwe. liquid metal fast breeder reactor demonstration plants.

1,000 Mwe. LMFBR Design Studies

Five reactor manufacturers (Atomics International, Babcock and Wilcox, Combustion Engineering, General Electric, and Westinghouse), have performed studies on 1,000-Mwe. LMFBR plant designs. Argonne National Laboratory managed the studies for the AEC and is providing an in-depth evaluation of the designs.

The studies were primarily to determine, through the preparation

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[1] Uranium-233 and 235 (U^{233} and U^{235}) and plutonium-239 and 241 (Pu^{239} and Pu^{241}) are fissionable materials, and they produce more neutrons than are needed to maintain a nuclear reaction. So fertile material, such as uranium-238 (U^{238}) or thorium-232 (Th^{232}) is used with the most suitable fissionable material to obtain excess neutrons, converting the U^{238} or Th^{232} to Pu^{239} or U^{233}, respectively. The latter bred materials are fissionable and can be used in a reactor.

of conceptual plant designs, the research and development programs needed to achieve economic and safe LMFBR powerplants. The recommendations from these studies will be used in updating the AEC's LMFBR program plan and provide a base for the LMFBR demonstration plants.

Demonstration Plant

The design construction and operation of LMFBR demonstration plants are integral parts of the AEC's liquid metal fast breeder reactor development program to demonstrate the technical performance, reliability, ease of maintenance, and safety of LMFBR's in an operational environment. It would also provide information regarding the economics of later, larger-sized commercial LMFBR plants. The demonstration plants would be owned and operated by electric utilities on existing electric power systems.

The AEC intends to follow a two-phase approach for the demonstration plant project—a project definition phase, followed by a definitive contractual arrangement for the design, supporting development tests, construction, and operation of a specific plant. A cooperative arrangement is desired with a reactor manufacturer and an electric utility partner for this second phase which would allow a 300 to 500 Mwe. LMFBR powerplant to begin operation in the late 1970's.

The primary purposes of the project definition phase are to: (*a*) Define the proposed plant and site, and assess the technical and economic risks associated with the proposed design and site; (*b*) define the planning and scope of a project and related efforts necessary to bring the plant into being; and (*c*) establish the organizational contributions and operating relationships of all participating groups.

On May 28, 1969, the AEC issued an invitation for proposals from industry to conduct the project definition phase work. Proposals were received from Atomics International, Westinghouse, and General Electric. Each proposer has preliminary associations with one or more utility groups. On December 1, the AEC announced that it planned to contract with all three proposers. Contract negotiations and project definition phase work were underway at year's end.

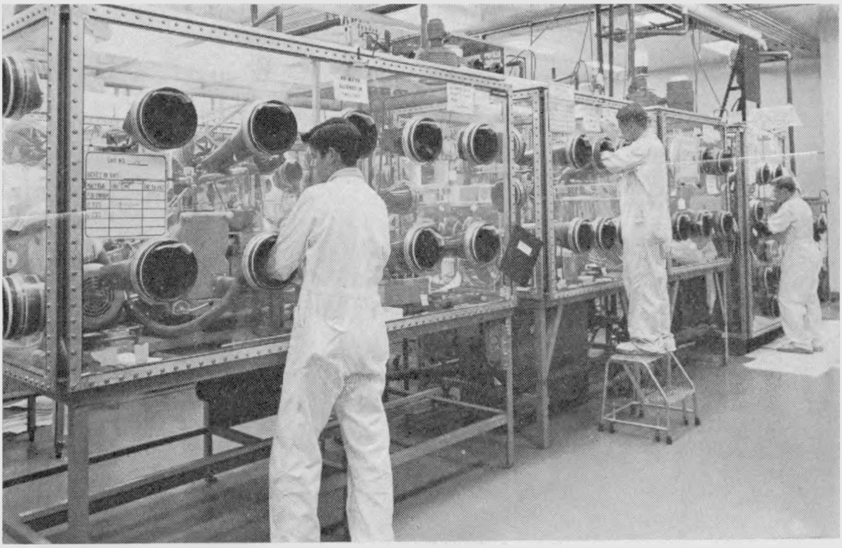
Test and Experimental Facilities

In addition to the preparations being made for construction and operation of near-term demonstration plants, the AEC is conducting the work necessary to develop satisfactory LMFBR fuels and materials,[2] construct a fuels and materials irradiation facility (see subsequent Fast Flux Test Facility item), and to develop LMFBR plant components, including adequate test facilities.

Experimental Breeder Reactor-2

The AEC's Experimental Breeder Reactor-2 (EBR-2) at the National Reactor Testing Station (Idaho) is the Nation's only operating fast-flux irradiation test facility for testing the fuels and materials being developed for fast breeder reactors. Additionally, the technology and engineering experience obtained from EBR-2 in such areas as plant design, components, instrumentation and control, sodium technology, physics, and safety are significantly important to the fast breeder program.

[2] See pp. 193–242, "Fundamental Nuclear Energy Research—1969."



The Fast Flux Test Facility is not scheduled for operation until 1974. However, development work on components for the facility is already underway at a number of contractor and AEC locations. Photo shows how fabrication of plutonium-bearing fuels is accomplished in glovebox lines at the plutonium development laboratory of The Babcock & Wilcox Co., Lynchburg, Va. Due to the radioactivity and extreme toxicity of plutonium, all operations must be performed in complete isolation. Once this fuel is in a completed form, it will be used in the prequalification phase of the AEC's FFTF/LMFBR fuel program.

Emphasis is being placed on irradiation testing and examination of fast breeder fuels and materials. The EBR-2 reactor plant is being upgraded and is carrying out a supporting research and development effort to increase its power level and improve its availability.

The plant factor [3] for 1968 and 1969 was 42 percent compared to only 20 percent in 1967. An extraordinary amount of nonpower testing associated with upgrading the plant and increasing the irradiation capability prevented a marked increase in the plant factor. However, unscheduled outages decreased for the sixth straight year.

Operating power of the EBR–2 was raised from 50 thermal megawatts (Mwt.) to 62.5 Mwt. during 1969 for a short preliminary test period to verify plant system capabilities at the higher level. However, 50 Mwt. operation will continue until adjustments to existing experimental assemblies in the core are completed in 1970, when routine 62.5 Mwt. operation will begin.

Successful use of instrumented fuel subassemblies provided, for the first time, sodium flow rates and fuel element temperatures and fission gas pressures for a fuel subassembly during EBR–2 irradiation.

The number of tests in the EBR–2, of fuels and materials increased during 1969. Nine unencapsulated oxide fuel assemblies, each containing 37 pins, closely representing fuel designs for LMFBR's were inserted in the EBR–2. The first of these assemblies reached burnup levels of more than 34,000 MWD/T (megawatt days per ton) without failure of any of the pins.

Eight encapsulated fuel assemblies and 12 encapsulated assemblies containing cladding and structural alloys are under irradiation; the maximum burnup reached by the fuel assemblies was 95,500 MWD/T, and the maximum neutron exposure to which metal specimens were subjected was 7.4×10^{22} neutrons per square centimeter.

In 1969, 11 assemblies were given post-irradiation examination; in 1970, 37 assemblies will be examined.

The additional number of assemblies and their more frequent examinations, when taken in context with the increased plant factor and reactor power, indicates a significant increase in total usefulness of EBR–2 as an irradiation test facility.

Design of the Hot Fuel Examination Facility (HFEF) will be completed in early 1970; excavation for it was completed during 1969. The HFEF, scheduled for 1972 operation, is being built at the EBR–2 site to provide irradiated fuels and materials examination capabilities required by the fast breeder program.

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[3] Plant Factor: Actual thermal megawatt (Mwt.) days produced divided by the product of Mwt. (rated) and the number of days in the period of time under consideration.

Liquid Metal Engineering Center

The Liquid Metal Engineering Center (LMEC) at Santa Susana, Calif., operated by Atomics International (AI), is a complex of component test facilities and supporting laboratories for testing and evaluating instrumentation, equipment, and components for liquid metal cooled fast breeder reactors. Additionally, the LMEC provides technical assistance and consultation services to the AEC, and has technical training programs for personnel from LMFBR contractors and utilities. It also has a Liquid Metal Information Center in which sodium technology information is compiled, and evaluated for industry.

The two major operational test facilities at LMEC are the Sodium Component Test Installation (SCTI) and the Large Component Test Loop (LCTL). SCTI design changes and repairs were completed in 1969 and operations for testing LMFBR steam generators and intermediate heat exchangers were reinitiated. Operation up to 12 Mwt. was demonstrated at exit steam conditions of 1,050° F. and 2,200 p.s.i.g. With some modifications, the SCTI will accommodate testing of advanced prototype steam generators.

Tests of instruments and small components for sodium reactors are being carried out in the LCTL. The facility is used to thermally cycle and steady-state test a variety of components and subsystems that will provide useful data for the FFTF and LMFBR plant programs.

A major facility in the design stage is the Sodium Pump Test Facility (SPTF). This facility will provide means for proof-testing pumps, and other critical components such as valves and large piping. In support of the sodium pump development program, test rigs for pump seals are available, and a pump bearing test facility is being designed.

Plutonium-Fueled Critical Experiments

There are four U.S. facilities in which plutonium-fueled critical[4] experiments can now be performed—Zero Power Plutonium Reactor (ZPPR) and Zero Power Reactor[5] No. 3 (ZPR–3) at the National Reactor Testing Station (NRTS) in Idaho and the Zero Power Reactors 6 and 9 (ZPR–6, ZPR–9) at Argonne National Laboratory.[6]

[4] Critical or criticality: The state in which a suitable amount, and configuration of fissionable material can sustain a chain reaction.

[5] ZPR: In developing designs for reactors, Zero Power Reactors (ZPR) are used to determine the size needed to sustain a fission reaction and other characteristics and features of the reactor and fuel. These "mock-up" reactors are operated at such low radioactivity levels that a coolant is not needed.

[6] See pp. 79–80, "Fundamental Nuclear Energy Research—1968," and pp. 254–257, "Fundamental Nuclear Energy Research—1969."

The ZPPR, the largest and newest of the facilities, became operational in April 1969 and has been used for experiments supporting the fast breeder reactor program, particularly accurate physics tests supporting the design of the FFTF. The ZPR-3 is being used to study areas of specialized interest to the Liquid Metal Fast Breeder Reactor (LMFBR) program. The modifications to ZPR-6 and ZPR-9 for plutonium use were completed in 1969. The ZPR-9 is being used for studies in connection with the FFTF, while the ZPR-6 is being used to study large plutonium systems.

Fast Flux Test Facility

Under contract with Pacific Northwest Laboratory (PNL), which has overall system management responsibility for the Fast Flux Test Facility (FFTF) for the AEC, design work on FFTF continued in 1969 by Westinghouse (Advanced Reactor Division, Pittsburgh, Pa.) responsible for the reactor plant, and by the Bechtel Corp. (San Francisco), the architect-engineer for general plant design. Atomics International (Canoga Park, Calif.) is the principal subcontractor to Westinghouse.

The Fast Flux Test Facility will be built on a 35-acre site at the Hanford Works near Richland, Wash. The FFTF's fast test reactor, with a design power level of 400 Mwt., will provide a fast flux more than double the capability of any existing test reactor.

Construction is scheduled to begin in 1970 with criticality expected in November of 1973. The FFTF, a key testing tool in the AEC's LMFBR program, will be used for irradiation testing and post-irradiation examination of fuels and materials being considered for use in future fast breeder power reactors. The reactor concept has a vertical core with provisions for closed test loops and individual instrumentation for each of the hexagonal driver fuel subassemblies and open loops.

Conceptual design of the reactor vessel was completed and Combustion Engineering (Chattanooga, Tenn.) was selected to design the reactor vessel, head, and associated equipment with an option for fabrication. Conceptual designs for the FFTF fuel elements and subassemblies were selected, the development of which will contribute significantly to the understanding of the stainless steel-mixed oxide fuel systems for LMFBR's.

Concepts were selected for the primary and secondary sodium heat transport systems, and the development pump specifications were prepared. Specifications for the reactor plant containment vessel are being developed. Preliminary test borings were completed at the site area.

As a result of extensive engineering studies by PNL, Westinghouse, and AI, a vertical reactor core with a built-in fuel handling machine was selected as the reference concept. Safety analyses reports are under preparation by PNL, Westinghouse, and Bechtel.

Southwest Experimental Fast Oxide Reactor

The Southwest Experimental Fast Oxide Reactor (SEFOR), a 20-Mwt. fast-spectrum, sodium-cooled reactor, first achieved a nuclear reaction in May 1969. The Fayetteville, Ark., reactor is owned by Southwest Atomic Energy Associates (SAEA), and operated by the General Electric Co. The Federal Republic of Germany, and Euratom were also financial participants.

The AEC supported the SEFOR preoperational research and development program and is supporting the present experimental test program in the reactor to demonstrate the safety of mixed (plutonium and uranium) oxide-fueled Liquid Metal Fast Breeder Reactors. During 1969, the low-power portion of the 3-year experimental program was completed. Use of the reactor at design power level was delayed because of problems with out-of-specification plutonium content in a portion of the fuel rods and poor radiographs of some of the coolant system welds. These problems were resolved, and regular operation was expected to begin early in 1970. The reactor will not be used to produce electricity.

OTHER BREEDER REACTORS

The AEC is examining breeder reactor concepts other than the LMFBR. Among these are the gas-cooled, light water, and molten salt breeder reactors.

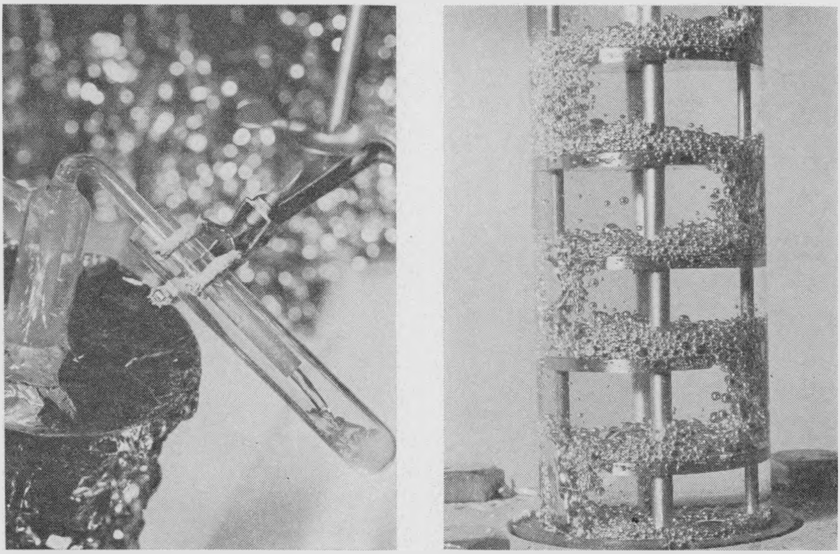
Gas-Cooled Reactor

Work on the gas-cooled breeder reactor concept has continued at Oak Ridge National Laboratory (ORNL) and Gulf General Atomic (GGA), (LaJolla, Calif.). The AEC work has stressed program development planning, including a detailed core development plan, as well as fuel irradiation and testing. Besides the AEC-sponsored work, more than 40 utilities joined GGA in a joint effort resulting in the conceptual design of a 330-Mwe. gas-cooled breeder plant.

Light Water Breeder Reactor

During 1969, work continued at the AEC's Bettis Atomic Power Laboratory on the development of a reactor core to demonstrate the potential for breeding in a completely light water reactor system. The Light Water Breeder Reactor (LWBR) concept is based on an advancement of the seed-blanket technology used in operation of the Shippingport (Pa.) Atomic Power Station.

The Light Water Breeder Reactor, which uses the seed-blanket reactor concept along with the thorium-uranium-233 fuel cycle, is the only known approach for significantly improving fuel utilization of light water reactors. The LWBR breeding demonstration is ex-



The First Photograph of a Typical Molten Salt Reactor Experiment (MSRE) fuel flowing at approximately 700° C. (1,292° F.) at Oak Ridge National Laboratory is shown at *left* above the arrow. The photograph demonstrates the ease with which such materials may be handled under proper conditions. In developing the reductive extraction processes for removal of protactinium and fission products from the Molten Salt Reactor, high-temperature solvent extraction columns are being studied for contacting molten fluoride salt with liquid bismuth. The photo at *right* shows a test of a baffled extraction column using water and mercury to simulate molten salt and bismuth. The photograph was taken as part of studies on flow patterns and interfacial area which supplement the quantitative hydrodynamic and mass transfer data.

pected to provide the basic technology which could make available for power production about 50 percent of the energy in U.S. thorium reserves, a potential source of energy many times greater than known fossil fuel reserves. This would represent a big increase in resource utilization compared to about 1 percent in present types of light water reactors. A successful demonstration of breeding in a light water reactor would demonstrate the technology which would allow building new light water breeder reactors and converting present and future pressurized water reactors to breeders.

Molten Salt Reactor

The Molten Salt Reactor Experiment (MSRE) at Oak Ridge National Laboratory provided research and development information on many of the key technical problem areas of molten salt breeder reactors. Operation of the MSRE continued in 1969 using a loading [7] of uranium-233 as fuel that had been inserted in 1968. As of December 12, 1969, the MSRE had achieved a total of 13,172 equivalent full power hours (EFPH) of operation, of which approximately 9,005 EFPH were with uranium-235 fuel and the remainder with the uranium-233 fuel. The reactor was shut down on that date.

The remainder of the molten salt reactor program at ORNL has been concerned with development of a reference conceptual design of a 1,000-Mwe. breeder reactor, and investigations in the vital areas of fuel reprocessing, materials, and components.

OTHER REACTOR CONCEPTS

Although the AEC has given the LMFBR (liquid metal fast breeder reactor) the highest priority for development, there are continued developments in other reactor concepts (*e.g.*, water-cooled and gas-cooled reactors) and in activities which are applicable to all nuclear power development, such as quality assurance, safety, reactor physics, environmental influences, and controls.

AEC WATER REACTORS ACTIVITIES

LaCrosse Reactor

The LaCrosse Boiling Water Reactor (Genoa, Wis.) reached full power of 50 Mwe. (net) for the first time on August 1, 1969, and

[7] See p. 90, "Annual Report to Congress for 1968."

completed 672 hours of full power operation on September 13. The plant was accepted by the AEC in November with several items remaining to be completed by Allis-Chalmers. The plant will be operated and maintained by the Dairyland Power Cooperative for a 10-year period.

Elk River Reactor

Discussions are underway between the AEC and the Rural Cooperative Power Association to define the scope of the decommissioning program for the Elk River (Minn.) reactor plant. The 22 Mwe. plant operated from 1964 through 1967 and has been shut down since February 1968 because of leakage in the primary reactor system.

BONUS Decommissioning

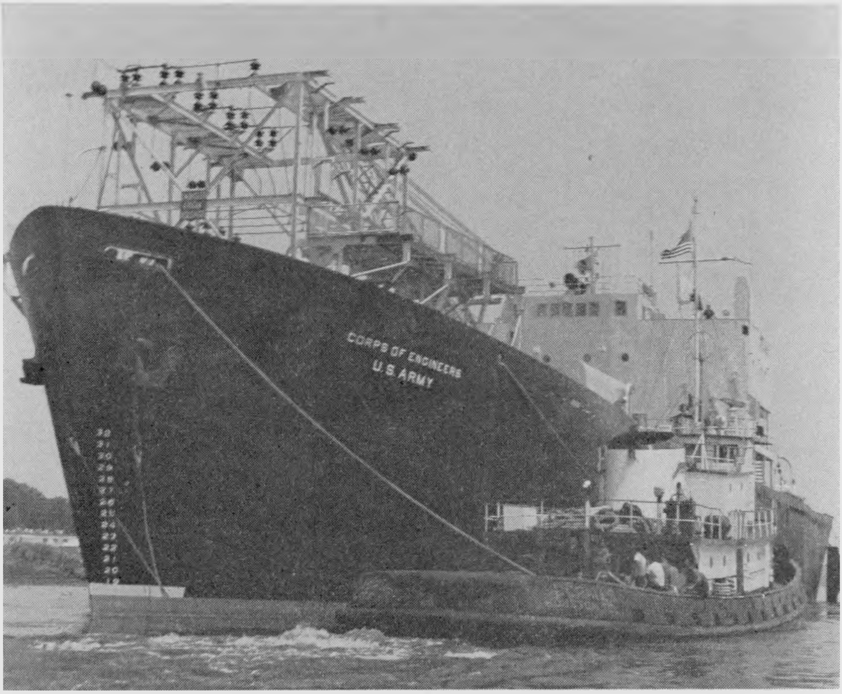
During 1969, decommissioning of the BONUS reactor in Puerto Rico centered on the removal of irradiated fuel from the plantsite, plant cleanup, system monitoring for decontamination effectiveness, and other steps required for deactivation of a nuclear plant. The Boiling Nuclear Superheat Power Station (BONUS) at Punta Higuera, P.R., was a joint project of the AEC and the Puerto Rico Water Resources Authority. The plant began operations in 1964 and provided technology concerning nuclear superheating. Technical problems and decreased interest in superheat boiling water reactors resulted in a 1968 determination to close the BONUS operation.

Plutonium Utilization Program

Significantly increasing quantities of plutonium are being produced by the water-cooled reactors used in today's and the near-future nuclear power stations. In a cooperative effort with industry, the AEC's plutonium utilization program is developing a sound technological base for the eventual safe, reliable, and economic recycle of this power reactor-produced plutonium for further use as a reactor fuel.

Major activities during 1969 were directed toward: (*a*) Obtaining essential recycle data; (*b*) effectively transferring this Government-developed technology to industry; (*c*) discontinuing operation of the Plutonium Recycle Test Reactor near Richland, Wash.; and (*d*) meeting the major objective of acquiring high burnup experience for mixed oxide fuel through irradiations in the Saxton Nuclear Experimental Reactor Project (Saxton, Pa.).

In addition, contracts were executed between Edison Electric Institute (EEI), and both Westinghouse and General Electric. Westinghouse will fabricate and evaluate, through irradiation in the San Onofre Nuclear Generation Station reactor (San Clemente, Calif.), four full-size plutonium-containing fuel assemblies. General Electric fabricated 32 fuel rods and inserted them, for evaluation through irradiation, in the Big Rock Point Nuclear Plant reactor (Big Rock Point, Mich.). These will be supplemented by three full-size fuel



The Army's MH–1A (Sturgis), first barge-mounted nuclear powerplant, was designed for towing to sites requiring significant amounts of emergency electrical power on short notice. The plant is capable of producing 10 Mwe., and can operate for 1 year without refueling. The MH–1A is presently supplying emergency power to the Panamanian power grid in the Canal Zone, having been towed there from Fort Belvoir, Va. The MH–1A has generated over 50 million kilowatt hours of electricity with an availability factor of more than 87 percent since startup in the Canal Zone on October 5, 1968. Another water-cooled military reactor, the PM–3A, was the Navy's first shore-based nuclear power reactor and the first reactor in Antarctica. By the end of 1968 the plant had operated above the goal of 80 percent availability for 2 years in a row (availability in 1968 was 85.5 percent), supplying heat and electricity for McMurdo Station. During 1969, the PM–3A had an availability factor of approximately 80 percent and a plant capacity factor of about 73 percent.

assemblies. Another fuel assembly will be fabricated later and irradiated in a large commercial reactor.

Under a contract between the AEC and the EEI, information developed by Westinghouse and General Electric under these contracts will be made available to the AEC; in exchange, the AEC will make available the required plutonium at a reduced base price for the calculation of lease, burnup, and loss charges.

GAS-COOLED REACTORS

High temperature gas-cooled reactors (HTGR's) have good neutron economy and, with the use of the thorium fuel cycle, can substantially extend the Nation's fuel reserves. The high efficiency associated with high temperature operation also substantially reduces the waste heat which must be rejected to the environment. The gas-cooled reactor development program is directed toward the early commercial application of this concept. Much of this basic technology could be applied to the later development of gas-cooled fast breeder reactors.

Peach Bottom Unit 1

On February 28, 1969, the 40-Mwe. HTGR [8] plant at Peach Bottom, Pa., was restarted after undergoing the second scheduled licensing inspection period following 300 full-power days of operation. Although there was further indication of fuel problems (fuel compact swelling resulting in cracked elements), the plant continued to demonstrate the promise of the HTGR concept. In general, systems and components have operated as designed and predicted, and maintainability has been adequately demonstrated.

The plant accumulated 450 full power days (453,600,000 kw.-hrs.) on October 3, 1969, and was shut down for the third scheduled technical inspection period. Examination of the core revealed 78 broken elements. It has been decided to remove and replace the first core with a second core during this shutdown to permit the plant to be ready for operation during next year's peak demand period.

Peach Bottom first became operable in 1966 and went into commercial operation June 1, 1967.

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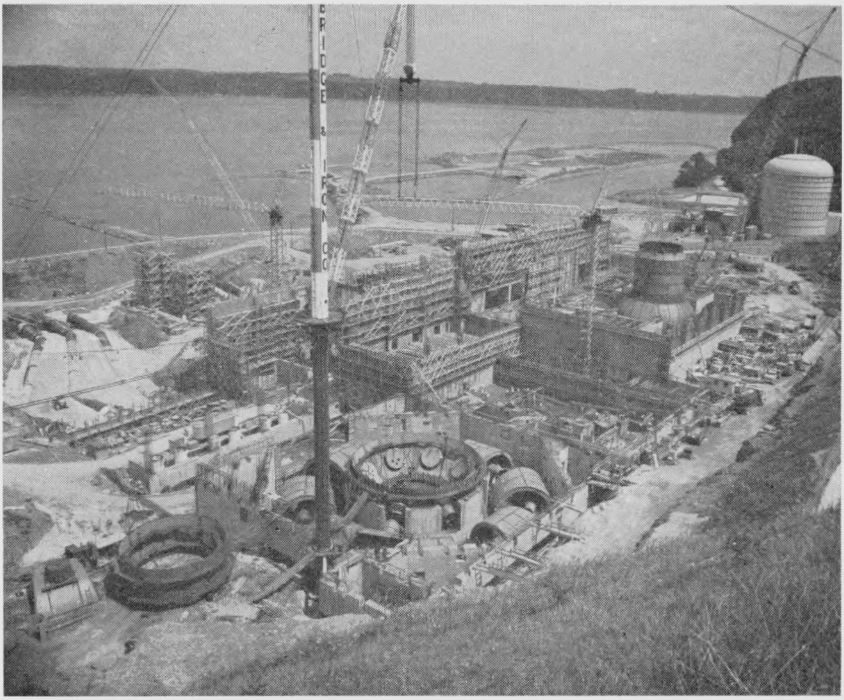
[8] Two additional boiling water units, for 1971 and 1972 operation, are under construction at the Peach Bottom site.

Fort St. Vrain

Construction of the 330-Mwe. Fort St. Vrain HTGR plant (Platteville, Colo.) is proceeding rapidly, and by yearend was approximately 50 percent complete. The prestressed concrete reactor vessel was nearly complete and installation of components inside the vessel had begun. Preliminary testing of components was successfully completed. An intensified design and analysis effort carried out concurrent with fabrication of the steam generators assisted in identifying and correcting problems encountered in this high-performance, first-of-a-kind component.

Initial operation of the Fort St. Vrain reactor is scheduled for 1972.



The Three Peach Bottom Reactors will provide some 2,170 Mwe. to the Maryland, Pennsylvania, New Jersey grid when Units 2 and 3 (foreground) are completed in 1970 and 1972. The three-unit power complex on the Pennsylvania shore of the Susquehanna River will be the first nuclear central station in the U.S. to use two different types of reactors. Unit 1, *upper right*, was the Nation's first commercial high-temperature gas-cooled reactor plant and has been in operation since 1967. It was developed by General Atomic (now Gulf General Atomic) for the Philadelphia Electric Co. and produces 40 Mwe. The two new units under construction will use General Electric boiling water reactors, each producing 1,065 Mwe. They, too, will be operated by Philadelphia Electric. The Bechtel Corp. is the engineer-constructor for the new plants as it was for Unit 1.

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ASSOCIATED ACTIVITIES

In addition to the research activities associated with the LMFBR, the AEC utilizes special test and experimental facilities for continued research applicable to other reactor concepts. The AEC is also working closely with industry in developing comprehensive engineering codes and standards for acceptable quality assurance in relation to projects.

TEST REACTORS

Thermal Test Reactors—ATR and MTR

The Advanced Test Reactor (ATR) at the National Reactor Testing Station (NRTS) in Idaho attained its design power level of 250 thermal megawatts (Mwt.) in August 1969 and is scheduled to be fully operational in 1970. The ATR, operated for the AEC by Idaho Nuclear Corp. (INC),[9] is the highest flux test reactor being used for materials testing. With its high thermal neutron flux—up to 2.5×10^{15} neutrons per square centimeter per second—the ATR will assist in the development of nuclear design data. In particular, the ATR will provide data for design of advanced naval reactor cores and advanced fuel systems and materials for the civilian power program. Pre-operational testing of the ATR was completed in the latter part of 1969. Initial indications are that fuel life in ATR may be more than double the design lifetime, thus materially reducing reactor operating costs.

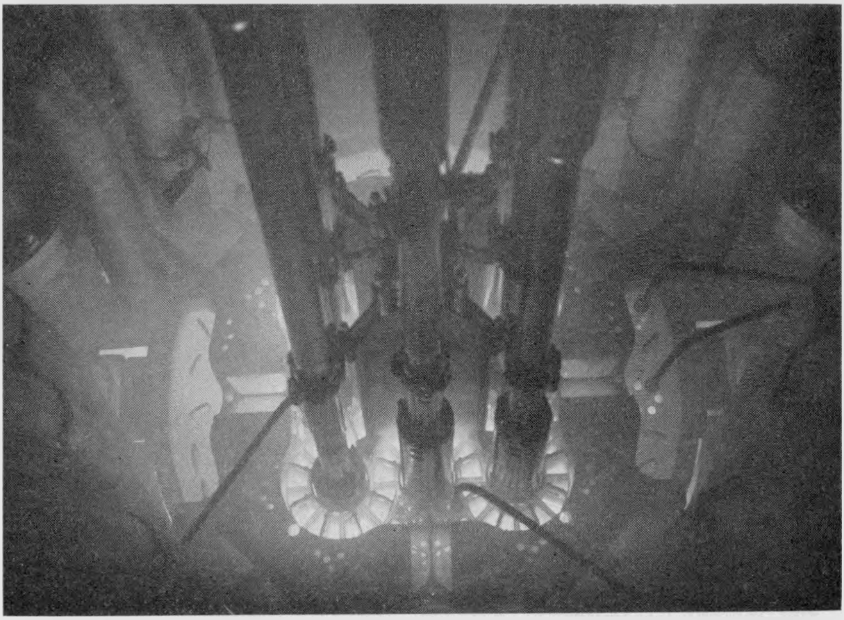
The 40-Mwt. Materials Testing Reactor (MTR), following 17 years of operation, was withdrawn from engineering irradiation test service in June 1969 and removal of all material and test apparatus was completed shortly thereafter. Prior to final shutdown and mothballing in mid-1970, the reactor will operate with the experimental Phoenix core[10] (a long-lived plutonium core with a high plutonium-240 content).

Safety Test Reactors—LOFT and PBF

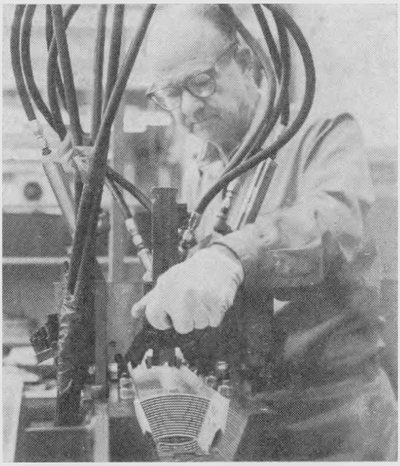
The design and construction of the Loss-of-Fluid-Test (LOFT) facility continued at the National Reactor Testing Station. This test facility will be used to simulate the effects of a major loss-of-coolant accident in a large light water power reactor. In June of 1969, the

[9] Under a 1969 merger, Idaho Nuclear Corp. (INC) was reorganized and is now jointly managed by Aerojet General Corp., Phillips Petroleum Co., and Allied Chemical Co. Phillips' nuclear operations at NRTS were merged into INC.

[10] See pp. 55–56, "Fundamental Nuclear Energy Research—1968."



Under 20 Feet of Coolant Water, part of the Advanced Test Reactor's (ATR) four-lobed, clover-leaf core is clearly outlined in photo *above* by the *Cerenkov* glow from nuclear operation at the AEC's National Reactor Testing Station in Idaho. The ATR achieved its design power level of 250 megawatts on August 16, 1969, during a series of preoperational tests preceding the start of sustained full power operation with inpile experiments in early 1970. It is the AEC's newest and most powerful reactor for obtaining design data through studying the behavior of nuclear fuels, coolants, and structural materials in a high-neutron-flow environment. The photo, taken through a quartz window in the reactor's top head, shows the unique serpentine arrangement of the fuel elements which permit variable power levels within the core. The straight pipes penetrating through and between the fuel lobes are inpile tubes for inserting test samples. The inpile tubes permit testing samples in different coolants and temperature and pressure conditions than those in the ATR core itself. The ATR is operated for the AEC by Idaho Nuclear Corp. Nuclear fuel elements for the ATR, like the one shown at *left* in a swaging machine, were fabricated at Atomics International, Canoga Park, Calif. The 66-inch-long assemblies have 19 curved-aluminum fuel plates which are precision spaced and held in an arc by aluminum side panels. Sandwiched within each fuel plate is a thin core of enriched uranium mixed with a small amount of aluminum and boron.



AEC prime contract for the LOFT project was transferred from the Phillips Petroleum Co., to the reorganized Idaho Nuclear Corp.

It is expected that reactor operation for the loss-of-coolant tests will begin in the mid-1970's.

The Power Burst Facility (PBF) is a pulse-type, oxide-fueled, epithermal, water-moderated reactor being constructed at NRTS as part of the Special Power Excursion Reactor Test (SPERT) complex. The project is under the technical direction of Idaho Nuclear Corp. Nonnuclear design by Ebasco Services (New York City) was essentially complete by the end of 1969. Howard S. Wright (Seattle, Wash.) is the construction contractor.

The primary purpose of the PBF is to study the various phenomena associated with fuel failure under thermal transient conditions on fuel assemblies representative of those considered for present and future reactor designs. The PBF is designed to generate power transients (excursion, moderate overpower, and loss-of-flow at power) producing controlled energy releases capable of destroying experimental fuel subassemblies placed in a capsule or an enclosed flow loop mounted in the reactor, without damage to the basic reactor itself. It is to be operated by INC.

By the end of 1969, the design of the facility was 99 percent complete and construction 56 percent complete. Completion is expected in the summer of 1970, with initial operation expected a year later.

DESALTING AND PROCESS APPLICATIONS

The AEC's nuclear desalting program continues to be directed toward analyzing, developing, and demonstrating nuclear reactor systems for desalting and other process-type applications. These activities are closely coordinated with the Office of Saline Water, Department of the Interior, which has responsibility within the Federal Government for desalting research and development.

Demonstration Plant Interest

During 1969, continued interest was exhibited by California utilities and water agencies in developing plans for a large-scale nuclear desalting demonstration project as a replacement for the previously-proposed Bolsa Island project.[11] Hearings to consider desalting's future in the State also were held by the California Legislature's Joint Committee on Atomic Development and Space.

[11] See p. 98, "Annual Report to Congress for 1968."

Puerto Rico Study

The Aguirre area on the south coast of Puerto Rico was determined to be the preferred site for further study of the energy center concept based on nuclear energy. Detailed studies are underway to relate industrial processes, project phasing, and other aspects to the economic development of the Commonwealth.

Oak Ridge National Laboratory Activities

The Oak Ridge National Laboratory (ORNL) continues to provide valuable support to the programs of both the AEC and Office of Saline Water. For the latter, ORNL is providing scientific and engineering support in basic water research and distillation development, as well as support for design and cost studies of various desalting processes. For the AEC, ORNL activities include technical evaluations, conceptual designs, component and system development, and other technical support for the AEC's nuclear desalting program. Of particular interest is the conceptual design and economic analysis of industrial and agro-industrial complexes [12] based on large nuclear power-desalting plants.

ENGINEERING CODES AND STANDARDS

The accelerated development and application of engineering standards, codes, and criteria in reactor development programs and projects that was initiated in 1967 continued in 1969. Approximately 70 approved standards—based on proven experience with primary coolant system materials, equipment, and engineering practices in reactor development projects—were available at the end of 1969. This group includes a comprehensive standard covering the requirements for acceptable quality assurance programs for these projects. Some 50 additional standards are in various stages of preparation or review prior to approval.

AEC and contractor reactor development personnel also continued to provide assistance in the preparation of industry and AEC regulatory standards, codes, and criteria.[13] In the industry group, a revised draft code for the periodic inspection of nuclear reactor primary coolant systems during the plant service life has been prepared by the

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[12] See p. 99, "Annual Report to Congress for 1968."

[13] See "Reactor Safety Criteria and Standards" in Chapter 6—Licensing and Regulating the Atom.

American Society of Mechanical Engineers (ASME) [14] to be issued early in 1970. Preparation of a comprehensive ASME code covering the mechanical and structural integrity of the overall nuclear power-plant primary coolant system and its major components has been initiated.

ENVIRONMENTAL RESEARCH

Environmental research directly affects the siting of nuclear facilities, such as reactors, chemical processing plants, and research laboratories. Placement and operation of these facilities require knowledge of the local hydrology, hydrogeology, geology-seismology, soils, meteorology, and effects of temperature changes of the water at a proposed site area. In addition, information is needed on transport, diffusion, and behavior of radionuclides to provide a basis for evaluating the environmental safety of proposed areas.

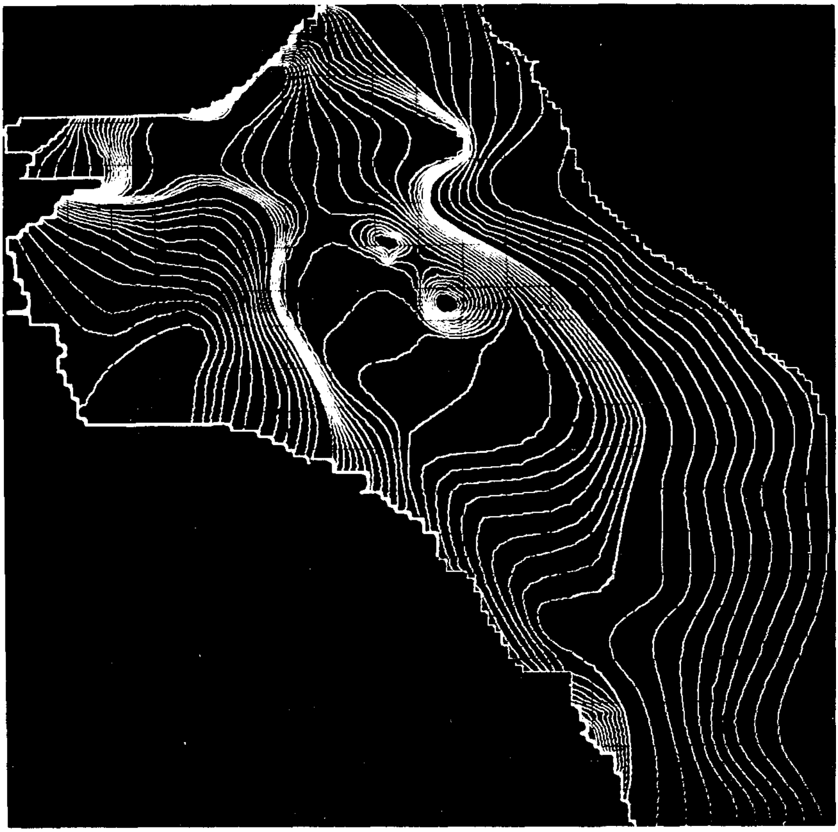
The AEC is carrying out an environmental research and development effort to develop the needed information. As part of this effort, the AEC has been supporting a comprehensive, interagency program with the Environmental Science Services Administration's U.S. Weather Bureau and U.S. Coast and Geodetic Survey; the Department of the Interior's U.S. Bureau of Mines, the Fish and Wildlife Service, and the U.S. Geological Survey; the Department of Health, Education, and Welfare's U.S. Public Health Service, and the Federal Water Pollution Control Administration.

Hydrology Research

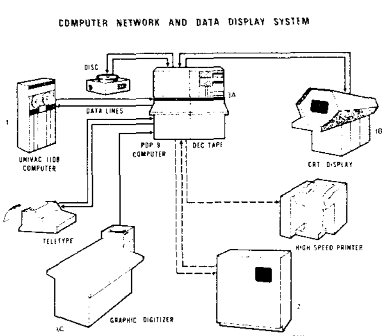
One of the major objectives of AEC-supported hydrologic research is to determine the behavior of radioactive liquid effluents which might be released to surface water environments. An example of the environmental studies in this area is the long-term, comprehensive stream investigation on the Clinch and Tennessee Rivers [15] below the Oak Ridge (Tenn.) National Laboratory (ORNL). Participating with the AEC's national laboratory were three Federal agencies (Tennessee Valley Authority, U.S. Geological Survey, and U.S. Public Health Service) and two State agencies (Tennessee Department of Public Health, and Tennessee Game and Fish Commission). It was concluded that for a relatively clean stream such as the Clinch River, the amount

[14] "Draft ASME Code for Inservice Inspection of Nuclear Reactor Coolant Systems," available from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, N.Y. 10017.

[15] See pp. 314–315, "Fundamental Nuclear Energy Research—1966."



Among Newer Techniques Developed at the Pacific Northwest Laboratory for studies of movement of ground water and surface water, those involving computer systems are proving to be most useful. Such a system is illustrated at *left*. As an example of work with the ground water, the contours of the water table beneath the Hanford area are shown *above* as they are photographed on the cathode ray tube (CRT) memory display. The three mounds on the water table are the result of the disposal of process waters over the Hanford operating years calculated with the ground water potentials as input data. If the volumes to be disposed in the future can be assumed, changes in the shape of the water table and the resultant flow of the water can be computed. Extension of the method to predict the increasing temperatures of river basins due to upstream industrial activities is a natural outgrowth of this work.



of radioactivity stored in the river bottom sediments and plant and animal life is small, and that any potential hazard from the release of activity from this "built-up reservoir" is negligible.

Columbia River Study. In work complementary to the Clinch River study, the occurrence, transport, and dispersion of radionuclides in the water and sediments of the lower Columbia River are being studied by the Pacific Northwest Laboratory and the U.S. Geological Survey (USGS).[16] The work bears directly on monitoring the safety of present and future practices of releasing slightly radioactive effluents from the production and power reactors near Richland, Wash. However, the work has general application to stream safety, for predicting radionuclide transport, computing concentrations at various stream stages, and understanding mixing and dispersion in rivers.

The results suggest that the ability of transported sediments in the Columbia River to take up and hold radionuclides is never exceeded regardless of flow stage.

Flume Study. Comprehensive field stream studies will not be possible on all major water courses where nuclear facilities will be built, so the AEC is sponsoring a project at the University of Texas (Austin) involving a 200-foot long model stream [17] which can be hydraulically and biologically controlled to simulate various stream environments. It may be used to develop a universal model of stream transport of radionuclides. Results of the study have shown that the plant and animal life of a stream can be important as a temporary radionuclide "reservoir" in sluggish, weed infested (highly productive) streams which are typical in certain areas of the country in the summer. An increase in the suspended sediment load of a stream will "rob" radionuclides from the life forms through shifts in the radiochemical equilibrium.

Statistical Occurrence Study. A study of extreme hydrologic events is being made by the U.S. Geological Survey to develop criteria for use in safety analyses, siting evaluations, and nuclear facility design. The work consists of studying the statistical occurrence of hydrologic events that would be hazardous to reactor facilities and operations, such as the maximum stream flow associated with floods, and periods of drought during which the minimum stream flow may be insufficient for dilution and dispersal of effluents normally discharged to streams. The work includes the definition, in terms of probability, of maximum and minimum limits for floods and stream flows. Secondary consequences, such as areas of temporary inundation during floods, erosive

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[16] See p. 38, "Annual Report to Congress for 1968."

[17] See pp. 40–43, "Fundamental Nuclear Energy Research—1968," and pp. 317–319, "Fundamental Nuclear Energy Research—1966."

effects on structures, and changes in transport of sediments carrying radionuclides, are also being studied.

Hydrogeology Aspects

AEC-sponsored hydrogeologic research is directed toward developing and evaluating methods of disposal of radioactive wastes from fuel reprocessing plants. Data on physical and hydrologic properties of relatively impermeable rocks are being developed to aid in selecting sites where liquid and solid waste can be stored or disposed of with a high degree of assurance of stability and integrity of the earth materials for thousands of years.

Oak Ridge National Laboratory has developed hydraulic fracturing methods for injecting cement grout [18] and waste mixtures into relatively impermeable shale underlying the AEC site. Research is being done to develop reliable economic methods of determining the suitability of other sites for waste disposal by this method. Based on data from Oak Ridge, the USGS has developed a mathematical model of land-surface uplift as a response to nearly horizontal hydraulic fracturing.

ORNL and the USGS are collaborating in experimental hydrofracturing and grout injection at the Nuclear Fuels Services, Inc., West Valley, N.Y., reprocessing plant.

Geology-Seismology

The AEC is sponsoring further geology and seismology investigations to aid in defining the earthquake potential of sites to permit adequate engineering solutions and insure safety.

A prototype geologic environmental map of the Los Angeles basin is being completed by the USGS to indicate areas that may involve special geologic, hydrologic, or seismologic considerations relevant to siting nuclear powerplants. The map, which is regional in nature, will be useful in directing attention to pertinent problems which need detailed investigation at a specific site. Similar maps of other geologic areas where reactors may be built may also be prepared.

Historical Assessments. Permanent displacement (faulting) of the ground surface is known to have occurred during historic earthquakes at many places in the world. As an aid to site assessment, the USGS has completed a study of historic surface faulting in continental

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[18] See p. 43, "Fundamental Nuclear Energy Research—1968," and pp. 177–180, "Fundamental Nuclear Energy Research—1964."

United States and adjacent parts of Mexico and is completing a study of historic faulting in other parts of the world.

Studies by USGS of small earth tremors and crustal strain, as tools for improving the capability for predicting earthquakes, and studying fault plane behavior, will be applicable to assessment of regional and local seismologic-geologic environments. To study fault plane behavior, clusters of highly sensitive seismometers along the San Andreas, Hayward, and Calaveras faults in California are being employed to locate the foci and determine the correlations between small earth tremors and local strain; procedures are also being developed for automatic data collection and the use of computers in these regional studies. Regional deformations and surface distortions that indicate accumulating crustal strain, possibly premonitory to earthquakes, are being measured to provide more understanding of the manner in which stored strain energy is released and how this influences earthquake potential.

Correlation Studies. The AEC sponsors studies of the amplification of seismic waves attributed to localized differences in thickness and properties of soils and sediments. Studies are being made to determine whether predictable correlations can be made by extrapolating readily obtainable microseismic (weak motion) data to strong motion behavior during earthquakes. The USGS is comparing ground motion amplitudes recorded in soils and sediments near the southern part of San Francisco Bay with those recorded on nearby bedrock outcrops, using both natural tremors and vibrations generated by underground nuclear explosions in Nevada. The U.S. Coast and Geodetic Survey (USC&GS) is investigating the possible correlation of local amplification effects during current weak earthquake activity and the unexpectedly severe local structural damage suffered in parts of Caracas, Venezuela, during a moderate earthquake in 1967. Environmental Research Corp. (Alexandria, Va.) is reviewing and assessing all available data from the AEC's Nevada Test Site to establish whether predictable correlations between weak motion data at the site can be compared with strong-motion data from underground nuclear explosions.

Geologic guidelines and criteria for reactor site selection and evaluation are being developed by the AEC in consultation with the USGS and USC&GS, other seismology experts, and the reactor industry. These guidelines will provide orderly procedures for selecting and evaluating sites in terms of local and regional geologic, seismologic, and hydrologic factors that must be considered in reactor design and construction in order to meet regulatory and safety requirements.

Soil/Structure Interaction

To further investigate the seismic loadings that might be experienced by reactors, the AEC sponsors studies of soil/structure interaction at the University of Toledo (Ohio). These studies are to define the modification of the ground motion which reaches the base of the reactor system due to the feedback of energy to the soil from the vibrations of the massive reactor complex itself. This feedback of energy potentially results in the reduction of vibration at the base of the reactor system, and consequently, in reduction of the loads imposed upon the reactor. The ability to define such effects will lead to an improved understanding of safety margins available in reactor design, and perhaps, to more economic designs.

Meteorology Tests

The meteorological research program being carried out by the Environmental Science Services Administration (ESSA) for the AEC is directed toward understanding atmospheric transport and diffusion.

The desire to site nuclear powerplants closer to urban centers has resulted in a number of studies to determine the differences in urban diffusion climates as compared to rural, thinly populated areas. Radar-tracked, constant-volume balloons floating a few hundred feet above the ground have been used to trace the three-dimensional airflow at Los Angeles, New York City, Columbus (Ohio), and Atlantic City (N.J.). The tests indicated that over Los Angeles, for instance, the air trajectories, rather than being straight-line, are extremely complicated, having many loops and reversals over land and over water. Therefore, an airborne effluent released seaward may reverse and travel landward within 12 hours. The results over New York City showed that travel of air over bodies of water such as the Hudson and East Rivers markedly decreased vertical motion, and therefore vertical diffusion, compared with travel over Manhattan.

Since postulated accidental releases of radioactivity are often considered on the basis of leakage from a containment building, it is necessary to know the added dilution effect of the aerodynamic flow around the building, especially during light wind, slow diffusion, conditions. Wind tunnel tests of a scale model of the EBR–2 reactor complex and full-scale tests based on actual winds at the NRTS in Idaho showed that aerodynamic effects of buildings caused three times the dilution expected from smooth terrain. A computerized technique has been devised to obtain wind field analyses and provide a more realistic basis for transport and diffusion research. Further field studies of various building shapes and sizes are being conducted at NRTS in cooperation with AEC-sponsored wind tunnel simulation at the Colorado State University (Fort Collins).

Thermal Effects

Research is being carried out by the Pacific Northwest Laboratory and the Chesapeake Bay Institute of Johns Hopkins University (Baltimore) to develop a capability for predicting water temperature distribution at proposed nuclear powerplant sites.

Practical Demonstration. A mathematical model developed in connection with the operation of the Hanford plutonium production reactors for use on the Columbia River has been applied sucessfully by the Pacific Northwest Laboratory to the Deerfield River [19] below the Yankee nuclear plant in Massachusetts, and the Illinois River below the new Dresden 2 and 3 plants now under construction at Morris, Ill. More recently, the method was applied to a large segment of a river system, the upper Mississippi River Basin, which is expected to experience a rapid growth in power production. Efforts are now proceeding to determine the capacity of the Ohio River Basin for suitable siting of nuclear steam-electric generating plants.

Evaluation of Thermal Discharges. In planning for thermal discharges into a river, one of the least understood activities is the estimation of the mixing zone immediately below the discharge point. Many questions have been raised as to the best way to carry out these discharges. Pacific Northwest Laboratory is employing several advanced techniques to evaluate the interaction of thermal discharges from the Hanford nuclear station with the highly regulated regime of the Columbia River below Priest Rapids Dam. The research programs on the Columbia River are concerned with modelling and with the interaction of migratory fish in the immediate zone of mixing. Survival models have been developed which predict the mortality and equilibrium loss of young salmon under conditions of fluctuating but injurious temperatures, such as those occurring in many industrial waste outlets. These models should prove useful in the initial planning stages of industrial and municipal release structures (*e.g.*, ability to predict the loss of fish as a result of a given discharge design). It will also be possible to examine other aspects of ecological loss besides loss of fish. Ultimately, such models will permit the delineation of boundary conditions for plant design, not only as regards thermal releases

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[19] See pp. 40, 41, "Fundamental Nuclear Energy Research—1968."

but also chemical toxicants. Similar resistance patterns have been shown by fish exposed to various toxic substances.

Tidal Studies. During the past several years, the AEC has supported research and development work at the Chesapeake Bay Institute directed toward predicting the physical processes of movement and diffusion in tidal areas such as estuaries. Hydraulic models and theoretical studies have been extended to develop improved methods for predicting the distribution of excess temperature resulting from the discharge of a heated water into bay and coastal waters. Field studies to determine the temperature patterns in receiving waters resulting from operation of a number of large powerplant installations are being planned. In these studies, it is hoped that the hydraulic model and theoretical studies which have been carried out will be validated.

Reprocessing Plant Siting

In cooperation with Oak Ridge National Laboratory and other AEC-contractor organizations over the last 2 years, the AEC has been studying the need and the bases for policy concerned with the siting of nuclear fuel reprocessing plants and related waste management facilities.

The results of the study provided the basis for publication in the *Federal Register* (June 3, 1969),[20] of a proposed AEC policy which would require the solidification of all high-level radioactive wastes within 5 years of generation at commercial reprocessing plants, and subsequent transfer of these wastes to a Federal waste repository no later than 10 years after generation. Industrial comments on this proposed policy have been received and are presently under AEC review.

The technical basis for this policy has largely been provided by AEC's Waste Solidification Engineering Prototype Demonstration Program at the Pacific Northwest Laboratory, and the studies on the disposal of radioactive waste in natural salt formations being conducted by Oak Ridge National Laboratory.

SUPPLEMENTAL RESEARCH REPORT

The more fundamental aspects of the AEC's reactor technology programs are summarized in the supplemental report, "Fundamental

[20] See item under "Nuclear Fuel Cycle Activities" in Chapter 6—Licensing and Regulating the Atom.

Nuclear Energy Research—1969."[21] Some of the material in Part Three—Reactor Technology Programs, include:

Nuclear Fuels and Materials

- A significant step toward the development of a high-performance mixed uranium-plutonium nitride fuel for future high gain breeder reactors was experimentally demonstrated by irradiations involving burnups (of up to 65,000 MWD/Ton) accompanied by low dimensional changes of fuel pellet diameter and volume. Based on the amount of dimensional change recorded, a burnup potential of 150,000 MWD/Ton is possible.
- The addition of chromium (15 wt%) to vanadium base alloys yields an alloy superior to stainless steel in strength and in resistance to fast neutron damage. A vanadium-chromium-titanium (V–15Cr–5Ti) alloy would increase the breeding ratio of a liquid-metal cooled fast breeder reactor and perhaps increase fuel element lifetime.
- Miniaturized thermocouples were developed to monitor center line temperature of fuel pins having a quarter-of-an-inch outside diameter. Thermocouple development involved the production of the smallest size thin wall tubes of ductile tungsten alloy ever produced and high purity hafnium oxide insulators 42-thousandths of an inch in diameter containing two holes 12-thousandths of an inch in diameter for the thermocouple wires. Performance of the sensor during 1,000 hour test was excellent.

Heat Transfer and Fluid Dynamics

- Improved mathematical expressions have been developed that reflect the differences for heat transfer with liquid metals and account for the effects that nonuniform distributions in heat flux have on the temperatures of reactor fuel, cladding, or coolant.
- Research shows how well-established engineering design formulas for convective heat transfer can be modified to apply to high temperature gas.
- Data obtained from tests and theoretical studies show effective damping of vibration is about 2.3 times greater at a typical coolant flow velocity of 30 ft/sec. than the valve measured in static flow. A knowledge of damping is needed to predict the mean amplitude of sustained vibrations.

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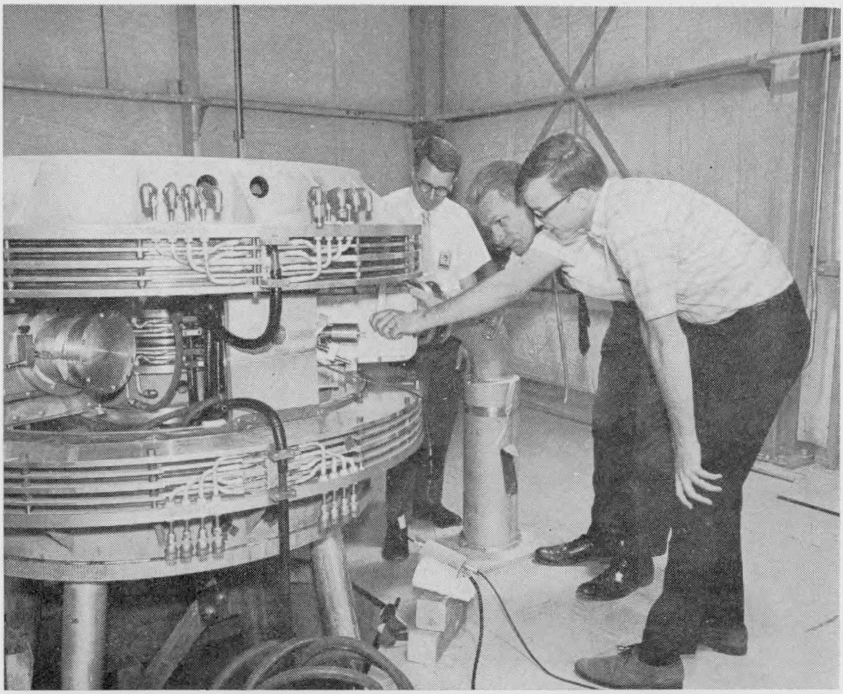
[21] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3.75.

Reactor Physics Research

- Alpha values for plutonium-239, a critical factor in achieving economic and safe operation with some fast reactor concepts, have been clarified with respect to recent conflicting measurements. Recent results confirm that alpha is higher between 200 ev. and 20 kev. than previously determined but not as high as indicated by preliminary results of other measurements.
- New techniques and instruments using ultrasonic waves to determine fuel, cladding, and coolant temperatures in liquid metal cooled fast reactors are being developed and tested.



One of the World's Most Sophisticated beta ray spectrometers began operating in 1969 at the National Reactor Testing Station in Idaho. This research device is being used to study the electron spectra from radioactive elements and learn more about their nuclear properties. The measurements obtained will provide needed comparisons with theoretical predictions. Another program being planned will obtain information on the position of various atoms in biological molecules and the changes in the molecule due to chemical reactions. Mechanical design for the beta ray spectrometer was performed for the AEC by Idaho Nuclear Corp. at the NRTS. A duplicate, based on the NRTS design, was completed in 1969 at the Oak Ridge National Laboratory.

Nuclear Reactor Safety Research

- Studies are being made on the behavior of reactor systems, components, and materials and the laws governing their thermal, hydraulic, mechanical, chemical, and neutronic behavior as they relate to safety. Specific data are being obtained to better understand the potential consequence of a loss-of-coolant incident and to reduce or eliminate the effects of such an incident.

Reactor Siting and Environment

- Quantitative data are being obtained on the transport, diffusion, and behavior of radionuclides in the environment. Aspects of the physical environment, such as thermal effects, geology, and meteorology, are being studied as they relate to, or affect nuclear powerplant siting or operation.

Chapter 6

LICENSING AND REGULATING THE ATOM

THE REGULATORY PROGRAM

The goal of the AEC's regulatory program is to assure, through a system of licensing and regulation, that the possession, use, and disposal of radioactive materials, and the construction and operation of reactors and other nuclear facilities are conducted in a manner consistent with public health and safety and the common defense and security. As a result of the increased interest shown by utilities during the last 5 years in using nuclear reactors for the production of electric power, there has been a significant increase in the AEC's licensing and regulation activities.

The Year—In Summary

During 1969, operating licenses were issued for four large nuclear electric plants, more than doubling installed nuclear power capacity to more than 4,000 megawatts of electricity (Mwe.). At yearend, 47 plants were under construction and applications for 24 power reactor construction permits were pending with AEC. A number of contracts and subcontracts for reactor vessels or components were awarded to foreign fabricators, resulting in extension of AEC regulatory inspections to manufacturing plants in several countries. Progress was made by the AEC and the industry in developing more comprehensive regulatory criteria and nuclear standards, and the AEC continued to emphasize the importance of quality assurance in the design, fabrication, construction, and operation of nuclear plants.

Jurisdictional problems arose with certain of the States regarding limits on releases of radioactivity from nuclear facilities. Public interest in the possible effects of nuclear facilities on the environment increased significantly during the year. Hearings conducted in October and November by the Congressional Joint Committee on Atomic

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Energy focused on the total problem of the environmental effects of producing electric power.

In the regulatory program for materials, further progress was made in simplifying AEC licensing procedures for radioisotopes. North Dakota, South Carolina, and Georgia assumed regulatory authority over atomic energy materials, making a total of 22 such States. (Regulatory actions of the AEC for safeguarding special nuclear materials from the standpoint of the common defense and security are included in chapter 2—Safeguards and Materials Management.)

Radiation Safety Record of Licensees

As a whole, AEC licensees continued to compile a good radiation safety record as reflected by results of inspections by AEC compliance personnel and the latest statistical reports on the industry. These included a work-injury experience survey of the atomic energy industry for 1968 by the U.S. Bureau of Labor Statistics, and records of film badge exposures in that year from major film badge processors (see "Compliance and Enforcement" section).

Licensed Reactors. The AEC has licensed the operation of 118 power, test, and research reactors since the beginning of civilian nuclear facility licensing in 1954. These facilities had compiled a total of 840 reactor-years of operation through December 31, 1969, without a radiation fatality or serious radiation exposure to operating personnel or the public.[1] Within this total, 20 central-station nuclear plants have been licensed for the generation of electricity, and accumulated about 96 reactor-years of operation through 1969 without an accident affecting public health and safety. No instance is known where the operation of these 20 nuclear power reactors has resulted in radioactivity releases exceeding annual limitations set by AEC regulations which are designed to protect the public against radiation hazards.

Materials Licensees. During the 23-year period since 1946, when the AEC began authorizing possession and use of atomic energy materials, only one radiation fatality has occurred among thousands of licensed activities. This was from a 1964 nuclear accident at a Charleston, R.I.[2] uranium scrap recovery plant. In AEC licensed opera-

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[1] The only fatal accident involving reactors in the United States occurred in 1961 at a nonlicensed Army experimental reactor which was designed for operation in remote areas. Three technicians died in a nuclear excursion of an early prototype reactor at the National Reactor Testing Station in Idaho, which was believed to have been caused in part by failure to follow prescribed maintenance procedures. No excessive offsite release of radioactivity resulted, and the public was not affected. (See pp. 35–39, "Annual Report to Congress for 1961," and p. 190, "Annual Report to Congress for 1962.")

[2] See p. 330, "Annual Report to Congress for 1964."

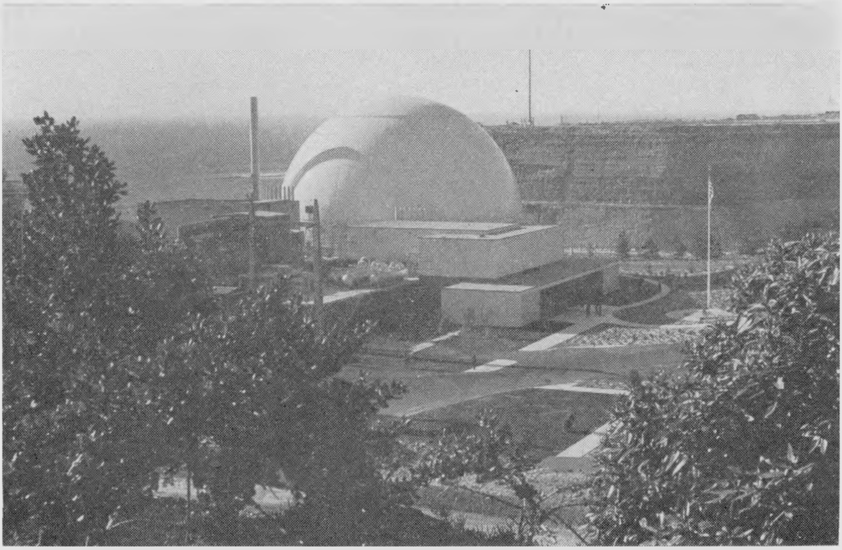
tions involving radioactive materials, only 12 other persons have received exposures serious enough to show clinical symptoms.

Congressional Hearings on Environmental Effects

Public hearings on the environmental effects of electric power production from all sources were begun in the fall of 1969 by the Congressional Joint Committee on Atomic Energy (JCAE). The hearings, which encompass the effects of all types of electric generating facilities, including both nuclear and fossil-fueled stations, are serving to focus more clearly on the total environmental problem of producing electric power.

In the first phase of the hearings,[3] conducted in October and November, testimony was received from representatives of Federal Govern-

[3] Committee prints of phase I of the JCAE hearings, "Environmental Effects of Producing Electric Power," are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at $4.50 each.



The Environmental Effects of Power Production drew the attention of Congress, as well as the public, during 1969, when the Joint Committee on Atomic Energy began public hearings on the environmental effects of electric power generation. The first phase—Federal Government witnesses—of the hearings was held in October and November; the second phase—State, industrial, environmental groups, and other public witnesses—is scheduled for early 1970. The hearings cover the areas of effects on air and water quality, as well as other environmental aspects, of all power generating sources including fossil-fueled stations and nuclear plants. The Bechtel Corp. photo of the Southern California Edison's San Onofre nuclear plant illustrates the clean operational environment of nuclear-fueled generating stations.

ment agencies having responsibility in the fields of air quality, water quality, and other environmental aspects associated with electrical generating stations. These included the AEC; the U.S. Departments of Interior, Agriculture, and Health, Education, and Welfare; Federal Power Commission, Federal Radiation Council; and Office of Science and Technology, Executive Office of the President.

The JCAE announced that the second phase of the hearings, scheduled for January 1970, would receive testimony from representatives of State governments, industry, environmental groups, and the public.

AEC License Fees

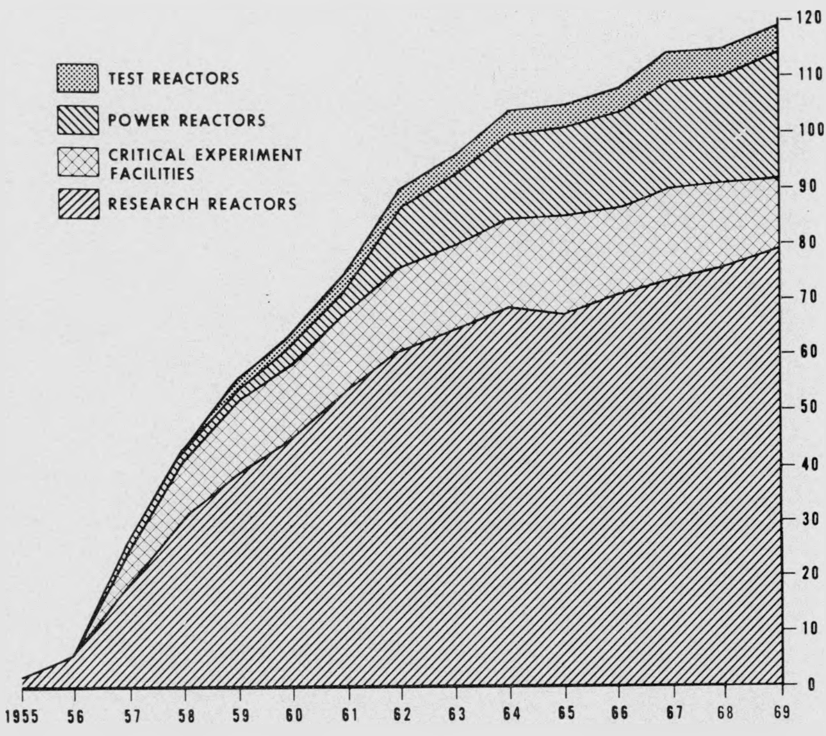
AEC licensee fee schedules in effect since October 1, 1968,[4] impose fees for: (*a*) Licenses to construct and to operate reactors and other production or utilization facilities; (*b*) licenses for byproduct ma-

[4] For fee schedules, see p. 143, "Annual Report to Congress for 1968," or 10 CFR part 170.

GROWTH OF LICENSED NUCLEAR REACTORS AND FACILITIES

DECEMBER 31, 1955 - DECEMBER 31, 1969

Licenses in Effect for Operation or Possession of Reactors and Other Facilities



terial (radioisotopes) of 100,000 curies or more in sealed sources used for irradiation of materials; (*c*) licenses for special nuclear material in quantities sufficient to form a critical mass (except plutonium/beryllium neutron sources); and (*d*) waste disposal licenses specifically authorizing the receipt of radioactive materials for commercial disposal. License fees paid to the AEC to date totaled $428,600.

REACTOR LICENSING ACTIVITIES

The number of nuclear electric plants nearing the operational stage continued to rise during 1969, and the number of construction applications for new plants increased over the 1968 rate. The installed electrical capacity of operable nuclear plants more than doubled as a result of operating license issuances for four large units producing an aggregate of 2,244 Mwe., and construction permits were issued for seven more units representing more than 6,000 Mwe.

There was increased emphasis on quality assurance programs for the large number of power reactors under construction and intensified work on safety criteria, standards and codes.

Status of Civilian Nuclear Power

At the end of 1969, central station nuclear electric plants in operation, under construction, or for which construction applications were pending with the AEC totaled 87 units, representing approximately 63,000 net Mwe. in capacity, as follows:

- Sixteen authorized to operate, with total capacity of 4,291 Mwe.; [5]
- Forty-seven under construction, with more than 37,600 Mwe. total initial capacity;
- Twenty-four construction applications were pending for powerplants with an initial total design capacity of almost 21,000 Mwe.[6]

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[5] Includes AEC's nonlicensed Shippingport (Pa.) Atomic Power Station. Does not include "N" reactor near Richland, Wash., which produces steam for the Washington Public Power Supply System's 790-Mwe. generating station. Licensed facilities include Indian Point Unit 1, Nine-Mile Point Nuclear Station and R.E. Ginna Unit 1 (N.Y.); Dresden Units 1 and 2 (Ill.); Peach Bottom Unit 1 (Pa.); Yankee Nuclear Power Station (Mass.); Enrico Fermi Unit 1 and Big Rock Point Nuclear Plant (Mich.); Elk River Nuclear Plant (Minn.); Humboldt Bay Unit 3 and San Onofre Nuclear Generating Station (Calif.); LaCrosse Boiling Water Reactor (Wis.); Connecticut Yankee Atomic Powerplant; and Oyster Creek Unit 1 (N.J.); does not include reactors which have been shut down permanently: Hallam (Nebr.) Nuclear Power Facility, Carolinas-Virginia Tube Reactor (S.C.), Pathfinder Atomic Powerplant, (S. Dak.), Piqua (Ohio) Nuclear Power Facility, and Boiling Nuclear Superheat Reactor (BONUS), Puerto Rico.

[6] Includes application for Malibu Nuclear Plant Unit 1 (Calif.), which is inactive, and applications for Seabrook Station (N.H.) and Bell Station (N.Y.), which have been postponed by the applicants.

In addition, utilities had contracted for 12 nuclear units totaling approximately 12,000 Mwe., for which the AEC had not received construction permit applications by yearend.

Reactors in Operation

The four large nuclear powerplants licensed to operate in 1969 included the first three to be rated at initial capacities of 500 Mwe. and above. This brought installed central station nuclear plant capacity to 4,291 Mwe., encompassing the output of 16 facilities. In addition, the AEC authorized operation of a major experimental power reactor (at Fayetteville, Ark.) and four research reactors, and authorized the dismantling of one prototype power reactor (in Puerto Rico) which had been shut down since 1967.

The operating experience of the nuclear reactors in service during 1969 was generally favorable, and showed no incidents affecting public health and safety.

The First Major Component—a 570-ton, 73-foot long nuclear steam generator—is shown arriving at the site of Duke Power Co.'s giant Oconee station now under construction in South Carolina. Built by Babcock & Wilcox at Barberton, Ohio, the unit is one of the heaviest single pieces of equipment ever shipped by rail. Two specially-built flatcars, each with 12 axles and a 300-ton load capacity, made up the train that carried the generator as far as Newry, S.C., a few miles from the site. There, the steam generator was transferred to a specially designed 240-wheel vehicle that carried it the final 7½ miles to the first of three containment buildings at Oconee. Two such generators, each containing about 170 miles of special alloy tubing, will be used in Oconee Unit 1 (841 Mwe.) which is scheduled for 1970 operation; two other 886-Mwe. nuclear units are under construction at the Oconee site for 1971 and 1972 operation.

New Electric Power Facilities

Oyster Creek–1. On April 9, 1969, Jersey Central Power & Light Co. was provisionally licensed to operate its Oyster Creek Nuclear Powerplant Unit 1 at low power levels to permit initial fuel loading and testing, pending modification of the standby gas treatment system, further evaluation of preoperational testing of containment isolation valves, and additional review of the quality of certain piping. The boiling water reactor, located in Ocean County, N.J., about 35 miles north of Atlantic City, became operational [7] on May 3, 1969. After satisfactory resolution of these matters, the AEC amended Jersey Central's license on August 1, 1969, to authorize full-power operation of the plant at 1,600 megawatts thermal (Mwt.). The plant reached the authorized 515 Mwe. power level on December 7, 1969.

Jersey Central's 1963 decision to build the Oyster Creek facility "on a competitive basis" with conventional plants, without Government financial assistance marked the beginning of a period of increasing activity by utilities in applying nuclear energy to the generation of electric power. The plant was originally scheduled for operation in late 1967, but discovery of weld defects in connections to the reactor pressure vessel led to a lengthy period of evaluation and repair. The Oyster Creek facility is capable of producing about 515 Mwe. at the present licensed power level, and has an ultimate net design capacity of 640 Mwe. It was built for Jersey Central by General Electric Co., with Burns & Roe as architect-engineer.

Nine Mile Point. On August 22, Niagara Mohawk Power Co. was provisionally licensed to operate its 500-Mwe. Nine Mile Point Nuclear Station on the shore of Lake Ontario, about 7 miles northeast of Oswego, N.Y. The boiling water reactor became operational on September 5. Presently authorized for 1,538 Mwt. operation, the plant has an ultimate design capacity of 1,780 Mwt., providing about 620 Mwe. General Electric furnished the nuclear steam supply system and turbine generator, and Stone & Webster Engineering Corp. managed construction of the project.

R. E. Ginna. The AEC issued a provisional operating license to Rochester Gas & Electric Corp. on September 19 for its 420-Mwe. (1,300 Mwt.) R. E. Ginna Nuclear Powerplant Unit 1, located on the shore of Lake Ontario, about 16 miles from Rochester. The plant, which became operational on November 9, is designed for a capacity of 490 Mwe. at a power level of 1,520 Mwt. The pressurized water reactor was designed and built for the utility by Westinghouse Elec-

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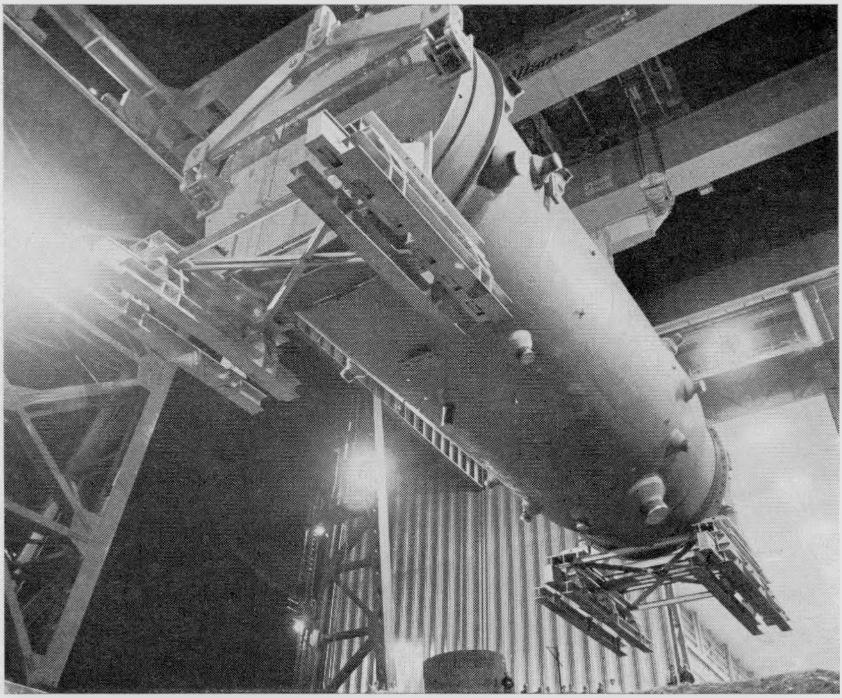
[7] In technical terms, "achieved criticality"—the amount and configuration of fissionable material sufficient to sustain a nuclear chain reaction.

tric Corp. and represents the first of the line of Westinghouse reactors currently being licensed for construction.

Dresden–2. On December 22, 1969, Commonwealth Edison Co. was provisionally licensed to operate its Dresden Nuclear Power Station Unit 2, the first nuclear generating plant in the 800-Mwe. class to be placed on line. Located at the site of Commonwealth Edison's Dresden Unit 1 near Morris, Ill., the boiling water reactor is licensed to operate at its full design power level of 2,527 Mwt., which will produce about 809 Mwe. net. Dresden–2 is the first boiling water reactor employing jet pumps inside the vessel, and was designed and constructed by General Electric. The AEC has a Commonwealth Edison application pending for a Dresden–3 operating license for a boiling water



An 800-Ton Nuclear Vessel for Commonwealth Edison's Dresden–2 unit dwarfed onlookers as it left the Babcock & Wilcox, Mount Vernon, Ind., facility, where it was fabricated for the General Electric Co. It is 72 ft. long and 22 ft. in diameter. Heat from the nuclear reaction contained in the vessel will produce steam sufficient to generate 809 megawatts of electrical power when the Dresden–2 unit goes into operation early in 1970. Dresden–3, another 809 Mwe. General Electric boiling water reactor unit, is expected to go into operation at the Morris, Ill., site later in the year. The initial unit, Dresden–1, which has been producing 200 Mwe. since 1959, was approaching the 10-billion kilowatt-hour mark at yearend.

reactor plant of similar capacity nearing completion at the same site. At yearend, Dresden-2 was being loaded with fuel for a scheduled January start. (It achieved criticality January 7, 1970.)

Other Actions. In other nuclear electric plant licensing actions, the AEC authorized an increase in the operating power level of the Connecticut Yankee (Haddam Neck, Conn.) plant and issued a full-term operating license for the Humboldt Bay plant in Eureka, Calif.

The Connecticut Yankee Atomic Power Co.'s provisional operating license was amended on March 11 to permit operation at its full power level of 1,825 Mwt.—a net increase in electrical capacity from 462 to 575 megawatts.

Pacific Gas & Electric Co. received a 40-year operating license in January for its Humboldt Bay nuclear unit, a 68.5-Mwe. boiling water reactor plant that had been operating under a provisional license since 1963.

On August 11 the AEC authorized dismantling of the Boiling Nuclear Superheat Reactor (BONUS) in Punta Higuera, P.R. This 16.5-Mwe. plant, which has been shut down since July 1967, had been operated for AEC by the Puerto Rico Water Resources Authority.

Experimental Fast Breeder Reactor

The Southwest Experimental Fast Oxide Reactor (SEFOR), near Fayetteville, Ark., was licensed in March to operate at low power for initial fuel loading and preliminary testing. It achieved a nuclear reaction in May. At yearend, authorization was pending for operation of the sodium-cooled facility at full power of 20 Mwt. SEFOR will not produce electricity but will be used to demonstrate reliability and safety characteristics of a fast breeder system fueled with mixed plutonium and uranium oxide ceramic fuel elements (see also Chapter 5—Reactor Development and Technology).

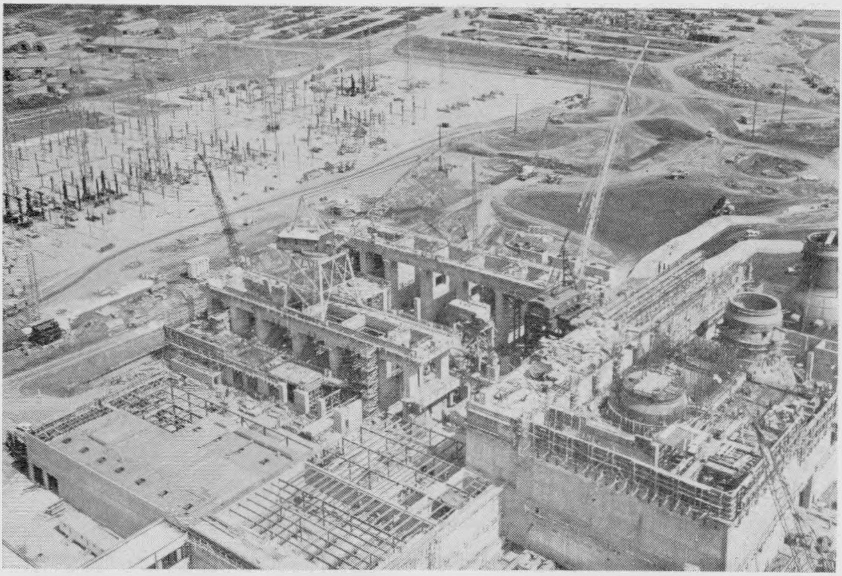
Reactors Under Construction

At yearend, 47 nuclear electric power units, all scheduled for commercial operation in the next 5 years, were in various stages of construction in 21 States. Their design capacities range from 330 Mwe. to more than 1,000 Mwe. each, representing an aggregate capability of some 37,600 Mwe.

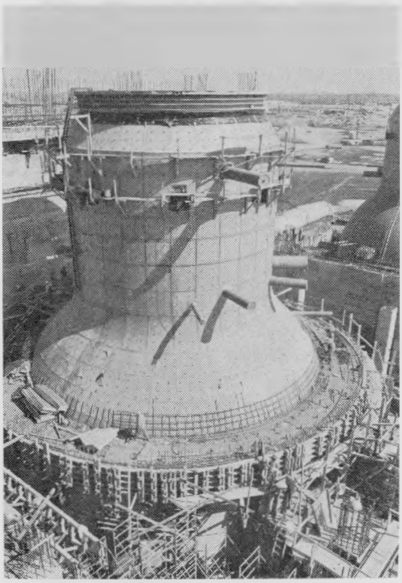
License applications for plants scheduled for near-term operation continued to mount; at the end of 1969, the AEC was reviewing proproposals from 12 applicants for operating licenses covering 17 units.

The processing of such applications begins more than a year in advance of projected operation.

Nine of these powerplants with a total design capacity of about 6,400 Mwe. are scheduled to begin operation in 1970 in Connecticut,



The Tennessee Valley Authority has under construction the first nuclear power reactors to be proposed in the 1,000-Mwe. range. Its Browns Ferry Nuclear Plant, located on the Wheeler Reservoir of the Tennessee River near Decatur, Ala., is one of two nuclear power stations where three identical units are being constructed simultaneously. Unit 1 is scheduled for commercial operation in 1971, and Units 2 and 3 in 1972. Each of the General Electric boiling water reactors will have an initial capacity of 1,065 Mwe. *Above* is a general view of the Browns Ferry complex taken during October. Units 1, 2, and 3 are shown in various stages of construction in right foreground. In photo at *left*, concreting of the biological shielding around Unit 2 drywell vessel is shown underway; shown partially at right is Unit 3. The great size of the units is illustrated by the small size of the workmen atop the concrete.



Illinois, Michigan, Minnesota, New York, South Carolina, and Wisconsin (see table 1).

Production Difficulties

Scheduling problems in producing reactor pressure vessels for the large number of plants underway and ordered resulted in the award of a substantial number of fabrication contracts to foreign firms. The AEC extended its regulatory inspection and surveillance activities to the overseas firms involved on a basis comparable with its program for determining technical capability and quality assurance at domestic plants. In March, a five-man AEC survey team visited the Rotterdam Dry Dock Co. in The Netherlands, which has contracts for a pressure vessel and vessel parts of internal structures for several U.S. reactor installations. Similar evaluations were made in September and October at the Societe des Forges et Ateliers du Creusot (SFAC), Le Creusot,

TABLE 1.—NUCLEAR POWERPLANT OPERATING APPLICATIONS UNDER REVIEW

(As of December 31, 1969)

Applicant	Plant	Date received	Unit size [1] (net Mwe)	Projected operation (year)
Commonwealth Edison Co.	Dresden 3 (Morris Ill.)	November 1967	809	1970
Millstone Point Co. et al	Millstone Point 1 (Waterford, Conn.).	March 1968	652	1970
Commonwealth Edison Co.,	Quad-Cities-1	September 1968	809	1970
Iowa-Illinois Gas & Electric Co.	Quad-Cities-2 (Cordova, Ill.).	September 1968	809	1971
Consolidated Edison Co. of N.Y., Inc.	Indian Point 2 (Buchanan, N.Y.).	October 1968	873	1970
Consumers Power Co.	Palisades (South Haven, Mich.).	November 1968	700	1970
Northern States Power Co.	Monticello (Monticello, Minn.).	November 1968	545	1970
Carolina Power & Light Co.	H. B. Robinson-2 (Hartsville, S.C.).	November 1968	700	1970
Wisconsin-Michigan Co., Wis-	Point Beach 1	March 1969	497	1970
consin Electric Power Co.	Point Beach-2 (Two Creeks, Wis.).	March 1969	497	1971
Florida Power & Light Co.	Turkey Point-3	May 1969	652	1971
	Turkey Point 4 (Turkey Point, Fla.).	May 1969	652	1972
Duke Power Co.	Oconee-1	June 1969	841	1970
	Oconee-2	June 1969	886	1972
	Oconee-3 (Seneca, S.C.)	June 1969	886	1973
Public Service Co. of Colorado	Fort St. Vrain (Platteville, Colo.).	November 1969	330	1972
Omaha Public Power District	Fort Calhoun 1 (Fort Calhoun, Nebr.).	December 1969	457	1971

[1] Electrical output at initial power ratings except for following units for which applicants have requested authorization to operate at "stretch" capacity: Dresden-3; Quad-Cities 1 and 2; Point Beach-1 and 2; Oconee-2 and 3.

France, and the Sulzer Bros., Ltd., Zurich, Switzerland; and an inspection-evaluation was scheduled for January 1970 at the Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI) in Yokohama, Japan. Schedules have been set for periodic followup inspections of fabrication progress.

A team from the American Society of Mechanical Engineers (ASME) conducted an inspection-evaluation of the SFAC plant concurrently with the AEC. The ASME participation was in response to a request by the State of Minnesota for assistance in assuring that the pressure vessel being fabricated for Prairie Island Unit 1 (near Red Wing, Minn.), will be equivalent in quality to ASME code-stamped vessels,[8] as required by Minnesota State laws.

By the end of 1969, 11 pressure vessels, or major portions of vessels, and a number of internal parts destined for U.S. reactor installations involved fabrication contracts placed by U.S. industry with overseas firms.

New Construction Permits

The AEC completed five initial licensing proceedings in 1969 and issued provisional construction permits for seven new nuclear power units to be located in Georgia, Maryland, Michigan, New York, and Pennsylvania. (See Table 2.)

Two twin-unit stations were among the plants authorized for construction in 1969. The D.C. Cook Plant (near Benton Harbor, Mich.) with two units rated at more than 1,000 Mwe. each, was not

[8] In the United States, the ASME's Nuclear Pressure Vessel Code is a recognized industrial standard in vessel fabrication. The AEC has developed additional regulatory criteria to supplement this code. See p. 127, "Annual Report to Congress for 1968;" see also Chapter 5—Reactor Development and Technology.

TABLE 2.—CONSTRUCTION PERMITS ISSUED FOR NUCLEAR POWERPLANTS—1969

Applicant	Plant	Date issued	Unit size (net Mwe)	Projected operation (year)
Indiana & Michigan Electric Co.	D. C. Cook-1	March	1,054	1972
	D. C. Cook-2 (Bridgman, Mich.).	March	1,060	1973
Baltimore Gas & Electric Co.	Calvert Cliffs-1	July	800	1972
	Calvert Cliffs-2 (Lusby, Md.).	July	800	1973
Consolidated Edison Co. of N.Y., Inc.	Indian Point 3 (Buchanan, N.Y.).	August	965	1973
Georgia Power Co.	E. I. Hatch (Baxley, Ga.)	October	786	1973
Jersey Central Power & Light Co. et al.	Three-Mile Island-2 (Goldsborough, Pa.).	November	810	1973

only the largest, but is also the first to use the Westinghouse-developed ice condenser concept in the containment design. The concept provides a low-temperature heat sink to rapidly absorb energy released in the unlikely event of a loss-of-coolant accident.

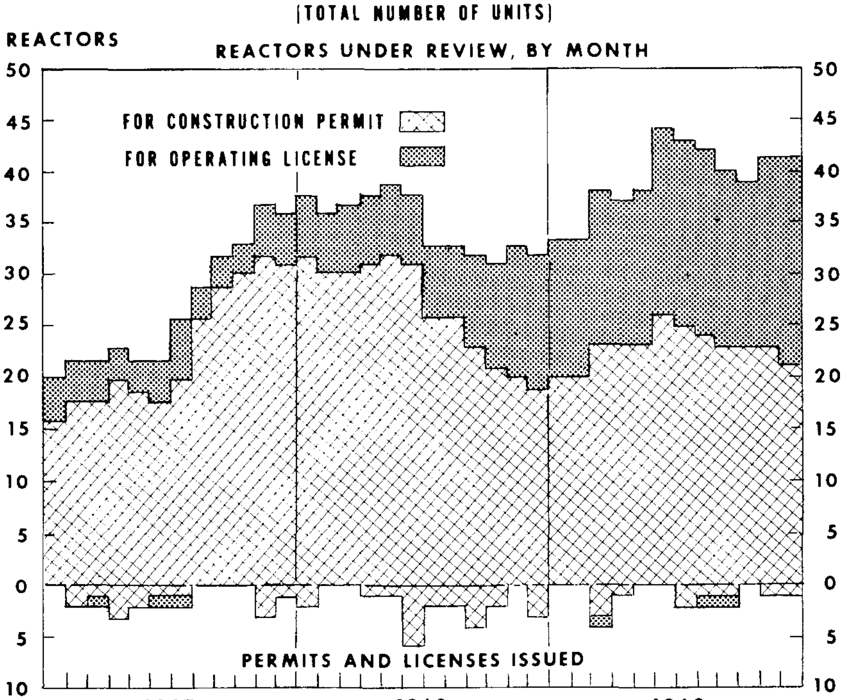
On March 10, Jersey Central Power & Light Co. amended its application for Oyster Creek Unit 2, changing the location to the Three Mile Island (Pa.) site of the Metropolitan Edison Co. The facility, redesignated Three Mile Island Unit 2, will be owned jointly by Jersey Central, which will design and construct it, and Metropolitan Edison, which will operate and maintain it.

Construction Applications Increase

Eleven utilities filed construction permit applications for 14 nuclear power units during 1969, compared with 10 applications for 13 reactors in 1968. At yearend, 19 applications for 24 units were pending with the AEC (see Table 3).

Of particular interest among the 1969 applications is a proposal

NUCLEAR POWER REACTOR APPLICATIONS AND APPROVALS,
(TOTAL NUMBER OF UNITS)



of Consumers Power Co. of Michigan to construct the dual-purpose Midland Nuclear Power Plant on the Tittabawassee River near Midland, Mich. Twin Babcock & Wilcox pressurized water reactors would be built immediately adjacent to the Dow Chemical Co.'s industrial complex in order to furnish process steam and a portion of the electric power to Dow. Combined net electrical capacity of the two units

TABLE 3.—NUCLEAR POWERPLANT CONSTRUCTION APPLICATIONS UNDER REVIEW
(As of December 31, 1969)

Applicant	Plant	Date received	Initial power (net Mwe)	Projected operation (year)
Los Angeles Dept. of Water & Power.	Malibu [1] (Corral Canyon, Calif.).	November 1963	462	1975
New York State Electric & Gas Corp.	Bell Station [2] (Lansing, N.Y.).	March 1968	838	----------
Long Island Lighting Co	Shoreham Station (Shoreham, N.Y.).	May 1968	819	1975
Pacific Gas and Electric Co	Diablo Canyon-2 [3] (Avila, Calif.).	July 1968	1,060	1974
Carolina Power & Light Co.	Brunswick-1 [4]	July 1968	821	1974
	Brunswick-2 (Southport, N.C.)	July 1968	821	1976
Tennessee Valley Authority	Sequoyah 1	October 1968	1,124	1973
	Sequoyah-2 (Daisy, Tenn.)	October 1968	1,124	1974
Iowa Electric Light & Power Co.	Duane Arnold-1 (Cedar Rapids, Iowa).	November 1968	545	1973
Power Authority of the State of New York.	James A. Fitzpatrick (Scriba, N.Y.).	December 1968	821	1973
Consumers Power Co	Midland-1	January 1969	492	1974
	Midland-2 (Midland, Mich.)	January 1969	818	1975
Duquesne Light Co	Beaver Valley (Shippingport, Pa.).	January 1969	847	1973
Florida Power & Light Co	Hutchinson Island (Ft. Pierce, Fla.).	January 1969	800	1973
Millstone Point Co. et al	Millstone Point 2 (Waterford, Conn.).	February 1969	828	1974
Virginia Electric & Power Co	North Anna 1	March 1969	845	1974
	North Anna-2 (Mineral, Va.).	March 1969	845	1976
Public Service Co. of New Hampshire.	Seabrook-1 [2] (Seabrook, N.H.).	April 1969	860	----------
Detroit Edison Co	Fermi 2 (Lagoona Beach, Mich.).	April 1969	1,126	1974
Consolidated Edison Co. of N.Y., Inc.	Nuclear Unit 4	June 1969	1,115	1976
	Nuclear Unit-5 (Verplanck, N.Y.).	June 1969	1,115	1977
Portland General Electric Co	Trojan Plant (Rainier, Oreg.).	June 1969	1,106	1974
Toledo Edison Co	Davis-Besse (Oak Harbor, Ohio).	August 1969	872	1974
Alabama Power Co	Joseph M. Farley Nuclear Plant (Dothan, Ala.)	October 1969	829	1975

[1] Application inactive.
[2] Postponed indefinitely by applicant.
[3] Public hearing on application scheduled in January 1970.
[4] Public hearing held in December; awaiting decision of an atomic safety and licensing board.

would be about 1,310 Mwe., and about 4 million pounds per hour of process steam would be produced.

In August, the Public Service Electric & Gas Co. of New Jersey announced plans for twin 1,100-Mwe. boiling water nuclear power reactors to be located on Newbold Island in the Delaware River, 4½ miles south of Trenton, N.J., and 11 miles northeast of Philadelphia, Pa. One unit is planned for operation in 1975 and the other in 1977. In advance of filing the application, the utility requested a preliminary site evaluation by the AEC. In September, the AEC's Advisory Committee on Reactor Safeguards reported the Newbold Island site "is not unacceptable with respect to the health and safety of the public" for a plant with the general characteristics described by the company and if designed in accord with certain features specified by the committee.[9]

Two Plants Postponed. In April, the New York State Electric & Gas Corp. announced indefinite postponement of its plans to build a nuclear powerplant on Cayuga Lake (N.Y.) in order "to provide more time for additional research in cooling systems for thermal discharge from the plant, and for consideration of the economic effect of such systems." Plans for the Bell Station, for which the utility had submitted a construction permit application in March 1968, had been the subject of local controversy over possible environmental effects on Cayuga Lake. In November, the Public Service Co. of New Hampshire announced deferment of plans for the projected Seabrook Nuclear Station as a result of a decision by one of the participants not to contribute to the funding. The application had been filed in April 1969.

Reactor Operator Licensing

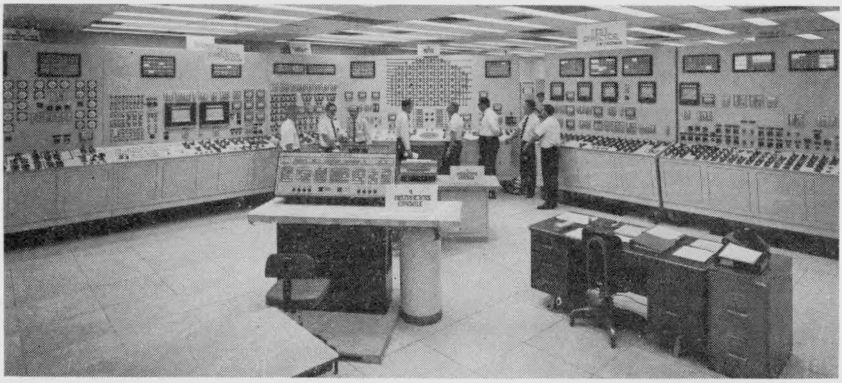
Individual licenses are issued, after examination requirements are satisfied, to operators who manipulate or supervise manipulation of reactor controls. During the year, the AEC issued, amended, or renewed 315 operator licenses and 376 senior operator licenses. Of these, 317 were new licenses. In addition, 110 applications were denied. Including previously issued licenses, 1,056 operator licenses and 740 senior operator licenses were in effect at the end of 1969.

To facilitate qualification of operators for the many nuclear plants under construction, the AEC began administering "certification ex-

[9] ACRS letter to the Commission of Sept. 10, 1969, with accompanying AEC Public Announcement M–219 dated Sept. 19, 1969, may be obtained by writing to the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

aminations" to individuals who plan to apply for licenses to operate reactors in the future. An individual may take an AEC examination after about 6 months of training at an operating reactor comparable to the facility he expects to operate. If successful, he receives a letter of certification that he has met the requirements of a reactor operator and is eligible to take an examination for a license at the facility where he is to be employed. During 1969, the AEC issued certification letters to 54 applicants.

The AEC also issued seven limited senior operator licenses in 1969 to individuals who will direct specialized fuel handling teams established by the Commonwealth Edison Co. for refueling activities at its Dresden and Quad-Cities multiple reactor sites.



Reactor Operator Training began in General Electric's nuclear powerplant simulator at Morris, Ill., during 1969. The facility is used to prepare candidates for the AEC examinations for operator licenses to handle the controls of Commonwealth Edison's new Dresden-2 plant. The simulator duplicates the control room of the nearby Dresden-2 facility. During 1969, Babcock & Wilcox installed a training simulator at Lynchburg, Va., and Westinghouse announced plans for a simulator facility to be installed near Zion, Ill.

Reactor Export Licenses

Two licenses were issued in 1969, both to Westinghouse Electric International Co., for the export of pressurized water power reactors. The first license authorized the export of components for an 810-Mwe. power reactor to be constructed near Gothenburg, Sweden, with component shipments expected to begin in June 1971. The second license authorized the export of components for a 350-Mwe. power reactor to be constructed near Breznau, Switzerland, with component shipments to begin sometime in 1970.

THE REGULATORY PROCESS

There are two principal stages in the licensing process for nuclear power reactors and other nuclear facilities: (*a*) the construction permit stage, at which the AEC determines there is reasonable assurance that a facility of the design and power proposed can be constructed and operated safely at the site selected by the applicant, and (*b*) the operating license stage, at which assurance is obtained that the facility has been constructed in conformance with the permit, and the facility is tested for safety purposes and brought to full power.

Three Separate Reviews for Construction

The AEC's initial licensing process for power reactors and other nuclear facilities involves three separate groups whose functions are concerned solely with protection of public health and safety and related regulatory responsibilities. An application to construct a nuclear facility is first reviewed by the AEC regulatory staff. In this technical evaluation, the advice and recommendations of a number of other Federal agencies and consultants in such fields as meteorology, hydrology, geology, seismology, and fish and wildlife resources are obtained, as appropriate. An independent review of each application also is conducted by the Advisory Committee on Reactor Safeguards (ACRS) which was established by law to advise the AEC. Upon completion of these reviews, a public hearing is conducted in the vicinity of the proposed site by an AEC atomic safety and licensing board (ASLB). The ASLB makes an initial decision as to whether a construction permit should be issued. This decision is subject to review by an atomic safety and licensing appeal board and/or by the Commissioners before becoming final.

An operating license application is also reviewed by the AEC regulatory staff and the ACRS, but a public hearing is not mandatory before this license can be issued.

Advisory Committee On Reactor Safeguards

The Advisory Committee on Reactor Safeguards (ACRS) held a total of 13 meetings during 1969, together with 79 meetings of ACRS subcommittees and *ad hoc* working groups. This included reviews of nine facilities at the construction permit stage, five facilities at the operating license stage, one preapplication site review and one preapplication review of a conceptual design for a large high-temperature gas-cooled reactor. Reports were provided to the AEC on 14 privately owned nuclear power facilities and fuel processing plants. In addition, the committee provided one report on refueling and maintenance procedures for naval reactors.

The ACRS Subcommittee on Reactor Safety Research met three times to discuss the AEC reactor safety research program. The Committee provided two reports to the Commission on the water reactor safety research program and one report on the Power Burst Facility. ACRS subcommittees and *ad hoc* working groups met to discuss general design criteria, seismic and geological siting and design, use of industry codes and standards, quality assurance, siting of reactors near airports, ferritic material toughness requirements, standards for protecton against radiation, population considerations in reactor siting, backfitting of production and utilization facilities, regulation of nuclear powered merchant ships, emergency procedures, reactor protection and control systems. Committee comments were provided to the AEC staff concerning these items. These groups also met to discuss siting of a proposed fast breeder reactor demonstration plant, and resolution of outstanding items related to large water-cooled power reactors.

ACRS members participated in the activities of AEC working groups on primary system quality, inservice inspection, use of foreign reactor pressure vessels, and the heavy section steel technology program. Committee members also participated in the AEC's overall study of the reactor licensing process. A list of current ACRS membership is included in Appendix 2.

Matters Outside the AEC's Jurisdiction

During the year, attention continued to be focused, in some reactor licensing proceedings and in Congress, on matters over which the AEC had no regulatory authority under the Atomic Energy Act of 1954. Principal among these were: (*a*) Concern over the thermal effects on the environment of cooling water discharges from nuclear electric generating plants, and (*b*) continuing efforts of smaller utilities—mostly municipal or cooperative power distributing systems—to participate in ownership of large generating plants planned by investor-owned utilities.

Thermal Effects

Intervenors in licensing proceedings and others have urged that the AEC consider the effects of heated water discharges from nuclear plants into adjacent bodies of water and impose license conditions concerning such effects. The AEC's position has been that it has no authority under existing legislation to consider thermal effects, as opposed to radiological effects, in its licensing proceedings. This position, which had been concurred in by the U.S. Department of Justice, was upheld in 1969 by a court in a review of the Vermont Yankee plant licensing proceeding (see "Judicial Review" section).

The AEC supported legislation introduced in the 91st Congress which would require applicants for Federal licenses to obtain advance certification from State water pollution control agencies with respect to compliance with applicable State water quality standards.

Antitrust Issue Raised by Smaller Utilities

The basic issue raised by smaller utilities seeking to share in large-scale nuclear power projects is that lack of opportunity to benefit from the anticipated low-cost power from such projects would be inconsistent with the antitrust laws.

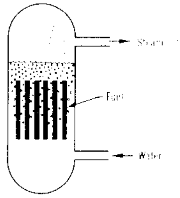
All AEC licenses issued through 1969 for nuclear power reactors have been issued under section 104b. of the Atomic Energy Act of 1954 for facilities involved in research and development activities leading to the demonstration of their "practical value" for industrial or commercial purposes. The AEC has specific statutory authority to consider antitrust matters in issuing "commercial" licenses for power reactors under section 103, but the Act does not permit commercial licenses until the Commission has made a finding of demonstrated practical value for a specific type of reactor pursuant to section 102.

Practical Value Consideration. In July, the AEC announced it would consider, by June 30, 1970, whether a finding of practical value within the meaning of section 102 of the Atomic Energy Act should be made for some types of light water nuclear power reactors.[10]

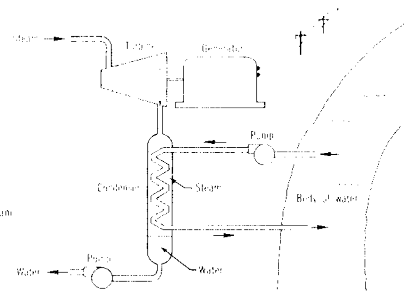
The Commission has twice before considered whether such a finding should be made, and on each occasion concluded that sufficient operating experience with the larger-size reactors was not available upon which to make the requisite findings. Sufficient information is expected to be available by mid-1970 from the 400-Mwe. and upward plants going "on stream" in 1968–69, to provide a sound basis, with reasonable extrapolation, to determine whether certain types of light water reactors are sufficiently developed to be of "practical value." Such a finding, among other things, would: (*a*) Require reporting of a proposed section 103 license issuance to the Attorney General for advice on antitrust aspects; (*b*) give preference to applications for power reactors

[10] AEC Public Announcement No. M–171 dated July 22, 1969.

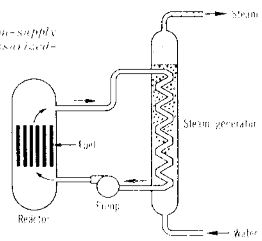
to be located in high-cost power areas if there are conflicting applications; (*c*) give preference to applications of public or cooperative bodies where there are conflicting applications; and (*d*) prohibit



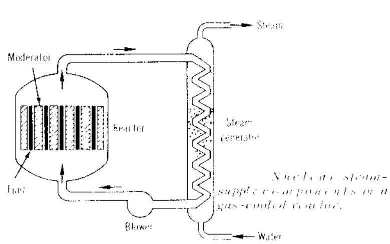
Nuclear steam-supply components in a boiling-water reactor.



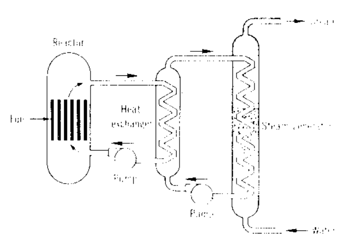
The power-generating portion of a nuclear power plant.



Nuclear steam-supply components in a pressurized-water reactor.



Nuclear steam-supply components in a gas-cooled reactor.



Nuclear steam-supply components in a liquid-metal-cooled breeder reactor.

Condenser Cooling Water Does Not Touch the reactor in a nuclear powerplant. Drawing illustrates how there is no physical contact between the coolant water and the steam generated by the heat of the reactor. The steam, having turned the electricity-producing turbine, condenses back into water as it passes around the coolant-water coils. At *left* are schematic drawings for the four major types of reactors in use or under development in the U.S. The power-generating portion of a nuclear powerplant (*above*) is the same for each concept. Only in the boiling-water type (*top left*) does the steam pass directly from the reactor to the turbine. In a pressurized water reactor, the reactor-heated water is cycled through a steam generator to create the turbine-driving steam; the gas-cooled system is the same, except that helium instead of water passes through the reactor to be heated. In the liquid-metal-cooled concept, the molten sodium passes through the reactor and into an intermediate heat exchanger where, in turn, liquid sodium is heated and then cycled through the steam generator.

waiver-of-use charges for source and special nuclear material, and require charges for nuclear fuel consumption.

Proposed legislation designed to eliminate the practical value distinction between sections 103 and 104b licensing also was pending in the Congress. Enactment of such legislation would remove the basis and need for a practical value rule making by the Commission.

ADJUDICATORY ACTIVITIES

During 1969, the Commission established the Atomic Safety and Licensing Appeal Board to review initial decisions in certain licensing proceedings. The Appeal Board is composed of the Atomic Safety and Licensing Board Panel chairman and vice chairman and a technically qualified third member who is designated by the Commission for each appeal hearing. Public hearings conducted by atomic safety and licensing boards were held throughout the country to consider applications for construction permits or operating licenses for nuclear facilities. The Commission reviewed several ASLB decisions. During the year, ASLB panel members participated in the AEC's overall study of the reactor licensing process.

Atomic Safety and Licensing Boards

The Commission established eight atomic safety and licensing boards (ASLB's) during the year.

Each three-man board, drawn from the Atomic Safety and Licensing Board Panel (see appendix 2), is composed of two technically qualified members and a chairman qualified in the conduct of administrative proceedings. The panel consists of 17 technical experts with extensive experience in industrial and academic nuclear programs and eight attorneys with experience in administrative procedures.

Public hearings before boards on applications for construction permits or operating licenses for reactors are generally conducted in the vicinity of the proposed site of the facility. After considering the record of the hearing, the board issues an initial decision. Before becoming final, this decision is subject to appeal by the parties to the proceedings and to review by the Commissioners and/or by the Atomic Safety and Licensing Appeal Board.

During the year, eight hearings were held in seven States. Applications for construction permits considered involved a total of 10 nuclear power reactors. One application for an operating license concerned a research reactor.

Four of the cases were contested proceedings [11] involving the applications of the Vermont Yankee Nuclear Power Corp.; Consolidated Edison Co. of N.Y., Inc.; Baltimore (Md.) Gas and Electric Co.; and Columbia University (N.Y.). The Vermont Yankee hearing was limited to the issue of the financial qualifications of the company to construct the plant. Four of the cases were uncontested and involved the applications of Indiana and Michigan Electric Co.; Georgia Power Co.; Metropolitan Edison Co.; and Carolina Power and Light Co.

In five of the above cases, the boards determined that provisional construction permits should be issued to the applicants. Included in this group were the applications of Indiana and Michigan Electric Co.; Baltimore Gas & Electric Co., Consolidated Edison Co., and Georgia Power Co., and Metropolitan Edison. In the Vermont Yankee case, after several days of hearing the board certified certain questions to the Commission regarding the future progress of the hearing and adjourned the hearing pending a Commission ruling. (See "Commission Review" section in this chapter.) At the end of the year, decisions involving the applications of Columbia University and Carolina Power and Light were still pending.

Atomic Safety and Licensing Appeal Board

With establishment of the Atomic Safety and Licensing Appeal Board, the Commission delegated to it authority to perform functions which would otherwise be performed by the Commission in: (*a*) Those proceedings on applications for licenses or authorizations in which the Commission has a direct financial interest, and (*b*) such other licensing proceedings as the Commission may specify. [12]

Facilities in which the AEC has a direct financial interest include those owned by the AEC, though not located at AEC installations, and operated for it under contract as part of the power generation facilities of electric utility systems. Also included are those facilities for which AEC has given direct financial assistance or has waived charges for fuel.

The final decision of the appeal board constitutes the final action of the Commission except that in cases other than those involving facilities in which the AEC has a direct financial interest, the Com-

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[11] Contested proceedings are those in which there is controversy between the AEC regulatory staff and the applicant concerning issuance of the license or any of its terms or conditions, or in which a petition to intervene in opposition to an application has been granted or is pending.

[12] Amendment to 10 CFR Parts 1, 2, 50 and 115, effective 30 days after publication in the *Federal Register* on August 19, 1969.

missioners have reserved the right to review the appeal board decision on their own motion on certain limited grounds that are specified in the regulations.

The Commission has assigned eight cases to the appeal board since its establishment in September of 1969, and one case comes under its cognizance by reason of the Commission's financial assistance to the project. An initial decision by an atomic safety and licensing board has been issued in one of these cases—that of the application of the Metropolitan Edison Co. This initial decision has become final following consideration by the appeal board.

Commission Review

During the year, the Commissioners completed or undertook formal review of two facility licensing matters upon appeals from initial decisions of atomic safety and licensing boards. In addition, the Commissioners responded to, or undertook review of, questions certified to them in two proceedings, and issued memoranda concerning two other proceedings in which no appeal had been taken from the ASLB decision.

Appeals From ASLB Decisions

Fort St. Vrain Nuclear Generating Station. The Commissioners reviewed, upon exception filed by the International Union, United Mine Workers of America, an ASLB initial decision authorizing the issuance of a provisional construction permit to the Public Service Co. of Colorado to construct a high temperature gas-cooled reactor in Weld County, Colo. In its decision on February 24, the Commission sustained the ASLB's holding that the operable economic feasibility of the proposed facility was not a proper matter for consideration as an independent licensing factor; and further concluded that there was no basis in the record for disturbing the ASLB's finding that a separate containment structure, in addition to the prestressed concrete reactor vessel, was unnecessary.

Indian Point Unit 3. The Commissioners reviewed, upon exception filed by an intervenor, an ASLB initial decision authorizing the issuance of a provisional construction permit to the Consolidated Edison Co. of N.Y., Inc., to construct a four-loop pressurized water reactor in Westchester County, N.Y. In a memorandum order of December 24, 1969, the Commission denied the exception.

ASLB Certified Questions

Vermont Yankee Nuclear Power Station. The ASLB convened to receive evidence on the financial qualifications of the Vermont Yankee Nuclear Power Corp., to design and construct the Vermont Yankee facility, certified certain questions to the Commission regarding the future course of the proceeding which are pending before the Commission.

Zion Station Units 1 and 2. An ASLB in its initial decision authorizing the issuance of provisional construction permits to the Commonwealth Edison Co., certified a question to the Commissioners regarding the proof required to demonstrate that an applicant is not owned, controlled or dominated by an alien, a foreign corporation, or a foreign government. In a memorandum issued on April 9, the Commission stated that the statutory requirements in this regard are satisfied if the record of a proceeding (which includes, in accordance with AEC regulations, sworn information by the applicant respecting its ownership and control) contains no evidence which would support a finding of alien ownership, control, or domination.

Commission Memorandums and Orders

Fort Calhoun Station, Unit No. 1. In an initial decision authorizing the issuance of a provisional construction permit to the Omaha Public Power District for a pressurized water facility in Washington County, Nebr., the ASLB recommended that the Commission attach certain conditions to the final decision relating to future design and construction and to the matter of quality assurance. In a January 22 memorandum and order, the Commission stated that its own review indicated no basis for disturbing the basic safety conclusions reached by the board, the regulatory staff, and the ACRS; and that the evidence presently of record was satisfactory concerning the matters which were the subject of the board's recommendations.

Calvert Cliffs Units 1 and 2. An ASLB, in a June 30 initial decision, authorized the issuance of provisional construction permits to the Baltimore Gas and Electric Co., to build two pressurized water reactors at a site on the western shore of the Chesapeake Bay in Calvert County, Md. The application was contested at the board hearing by an intervenor, the Chesapeake Environmental Protection Association, Inc., but no appeal was taken from the initial decision. The major contested issue at the hearing involved the discharge of radioactive materials from the plant; in particular, the liquid waste discharge containing tritium and the validity of the limits on such discharge established by 10 CFR Part 20 of the AEC regulations. In a memorandum issued on August 8, the Commission concluded that the ASLB's decision was supported by the record and that there was no evidence in the proceeding which would warrant departure from the standards specified in AEC regulations (10 CFR Part 20).

Judicial Review

Antitrust Issues

In three proceedings (Duke Power Co.'s Oconee Units 1, 2, and 3; Vermont Yankee Nuclear Power Station; and Peach Bottom Atomic Power Station Units 2 and 3)[13] intervening municipalities sought judicial review in the U.S. Court of Appeals for the District of Columbia Circuit contesting the AEC's licensing action. The municipals' basic contentions were that the reactors involved are not properly licensable as developmental facilities under section 104b. of the Atomic Energy Act and that, if so licensable, the Commission must consider antitrust factors in making its licensing determinations.[14] Subsequent to the initial oral arguments on these judicial appeals, the court ordered that a consolidated argument on the three cases be heard by all members of the court sitting *en banc*. That argument was held on June 26, 1969. On December 5, the court affirmed the Commission's licensing actions in the Duke and Vermont Yankee proceedings. The Peach Bottom proceeding is still pending before the court.

There have been three other decisions in which intervening municipals made exceptions to ASLB decisions[15] (Pilgrim Nuclear Power Station; Crystal River Unit 3; and Maine Yankee). The basic issues raised by the intervenors in these proceedings are the same as those taken before the U.S. Court of Appeals for the D.C. Circuit (see above). The exceptions to these ASLB decisions are pending before the Commission.

Thermal Effects Jurisdiction

On January 13, the U.S. Court of Appeals for the First Circuit (Boston), upheld the Commission's determination in the Vermont Yankee licensing proceeding that the AEC lacked regulatory jurisdiction over the thermal effects of effluent discharges from nuclear

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[13] See pp. 122–125, "Annual Report to Congress for 1968."
[14] See "Matters Outside the AEC's Jurisdiction" earlier in this chapter.
[15] See p. 125, "Annual Report to Congress for 1968."

powerplants.[16] On June 16 the U.S. Supreme Court denied the State of New Hampshire's petition for review by that tribunal.

Jurisdiction Over Regulation of Nuclear Facilities

In June 1969 the State of Minnesota issued a waste disposal permit to the Northern States Power Co. for the discharge of effluents from its Monticello Nuclear Generating Plant, under construction on the Mississippi River near Monticello, Minn. The plant, designed to produce 545 Mwe., employs a boiling water reactor furnished by the General Electric Co. It is scheduled for operation in 1970.

The Minnesota permit set limits for the discharge of radioactive effluents at a small fraction of the discharge levels permitted by AEC regulations (10 CFR part 20). The Northern States Power Co. subsequently filed suit in both the Federal and State courts to be relieved of these limitations on the ground that the Atomic Energy Act preempted to the Federal Government exclusive authority to regulate radioactive discharges from nuclear powerplants. These cases are still pending in the courts.

REACTOR LICENSING PROCESS REVIEW

Development of quality assurance criteria and a move to incorporate into AEC regulations industry-developed codes regarding the design, fabrication, and operation of nuclear powerplants highlighted the AEC's continuing program to improve the regulatory process for nuclear reactors during 1969. The Commission's effort to assure improved effectiveness of the regulatory program, while at the same time keeping regulatory procedures in step with the rapid expansion of the nuclear industry, was enhanced by the results of a year-long study by a review group which issued its report in June.[17]

Study Group Recommendations

The study group, representing the three principal components of the AEC regulatory system and the AEC's reactor safety research program, held discussions with industry representatives and other persons knowledgeable in the nuclear field in conducting its

[16] See pp. 123–124, "Annual Report to Congress for 1968."

[17] Recommendations and conclusions of the study group were issued in AEC Public Announcement No. M-149 dated June 25, 1969. The full report may be obtained by writing the Secretary, Attention: Chief, Public Proceedings Branch, USAEC, Washington, D.C. 20545. Members of the study group were listed on p. 126 of the "Annual Report to Congress for 1968."

technically-oriented review. Among its conclusions and recommendations were:

(*1*) The health and safety of the public has been adequately protected in the licensing and regulation process, and the high degree of conservatism in regulatory requirements has not been out of proportion to the need;

(*2*) The licensing review process at the construction permit stage has not been a limiting item in the time schedules for plant construction, but could become one in the future;

(*3*) Industry problems with the uncertainty and instability of regulatory requirements point up the need for a continuation and expansion of efforts by the AEC and the industry to develop comprehensive safety criteria, codes, and standards for reactors;

(*4*) Greatest emphasis and priority should be placed on application of quality assurance to the design, construction, and operation of nuclear plants;

(*5*) Greater advantage of the current degree of standardization in reactor and plant design should be taken by applicants and the regulatory groups within the present framework of the licensing process;

(*6*) Closer correlation between timing of industrial and regulatory decisions should be sought, including the possibility of changes in the scope and timing of the construction permit hearing and an earlier regulatory determination of site suitability; and

(*7*) The AEC regulatory staff should continue to be the only regulatory body to perform a complete technical review of each reactor application.

A number of actions initiated by the AEC during the year took into account the work of the study group. Further applications of its recommendations are being considered.

Policy on Backfitting

In April, the AEC published proposed amendments to its regulations [18] which would establish policy on the imposition of additional safety requirements after issuance of a reactor construction permit (backfitting), and further simplify the licensing process.

The continuing evolution of technology in the nuclear field frequently produces new or improved features or designs that may further enhance safety. To help reduce uncertainties for licensees as to the imposition of new requirements after construction has begun, the

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[18] Proposed amendments to Parts 2 and 50 of Title 10, Code of Federal Regulations, published in *Federal Register* on April 16, 1969. Summaries of all proposed and effective rule changes published during 1969 will be found in Appendix 5.

proposed criteria would provide that modifications would be imposed only if the AEC finds that the backfitting "will provide substantial, additional protection" required for public health and safety.

A feature of the proposed regulation change would eliminate the word "provisional" from construction permits, which would tend to conform terminology more closely with practice. Additionally, "provisional" operating licenses would be eliminated, thereby removing one step in the present licensing process. Any temporary limitations on operation considered necessary by the AEC would be incorporated as license conditions or technical specifications in the full term operating license.

Reactor Safety Criteria and Standards

During 1969, progress continued in the intensified program of developing comprehensive safety criteria and nuclear standards for light water power reactors. Cooperation between the AEC and industry and professional groups assured reflection of industrial experience and ideas in regulatory criteria.

An important step was taken in November with publication of proposed rule changes which would incorporate (by reference) industry-developed codes into AEC regulations.[19] This move was directed toward assuring that the most current versions of such codes are used in the design, fabrication, and inspection of systems and components of nuclear power reactors. New and improved industry codes [20] in such areas as pressure vessels, nuclear piping, and reactor protection systems have been developed for use in the design, fabrication, and inspection of nuclear components, but there has been a considerable time lag between their development and required use. Their proposed incorporation into AEC regulations is intended to assure that the improved practices prescribed by these codes will be used by the nuclear power industry on a more timely basis.

Industry Inservice Inspection Code

AEC personnel aided in the preparation of the "Industry-ASME Code for Inservice Inspection of Nuclear Reactor Coolant Systems." [21]

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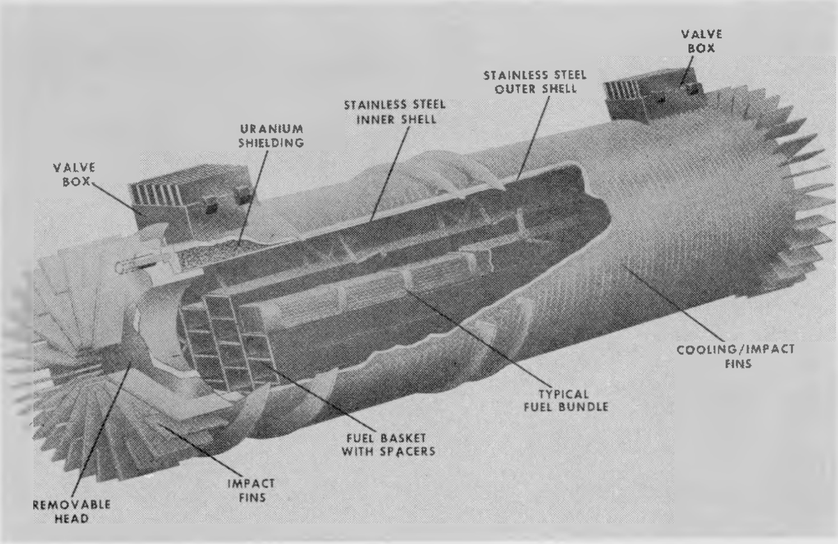
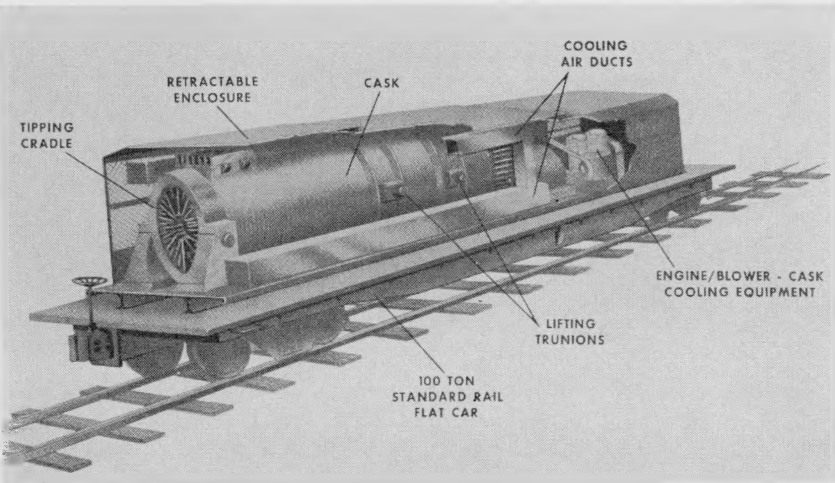
[19] Proposed amendments to 10 CFR Parts 50 and 115, published in *Federal Register* November 25, 1969, and described in AEC Public Announcement No. M-264, November 24, 1969.

[20] For example, the American Society of Mechanical Engineers' Code for Unfired Pressure Vessels, section III; the United States of America Standards Institute's Nuclear Piping Code; and the Institute of Electrical and Electronic Engineers' Criteria for the Design of Reactor Protection Systems.

[21] Draft ASME Code for Inservice Inspection of Nuclear Reactor Coolant Systems," available from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, N.Y. 10017.



One of the Shipping Casks presently being reviewed by the AEC's licensing staff is the General Electric IF300 Spent Fuel Cask which employs uranium as shielding material. The view *above* is a schematic cutout of the cask itself showing a typical fuel module and the main features of design. The loaded cask weighs between 125,000 and 135,000 pounds, depending on the type of fuel being shipped. The drawing *below* shows the cask in normal rail transport configuration which will be the primary transportation method.



Intended to be the basic industry standard for continuous inspection and safety surveillance during operating life of light water power reactors, the code will be used by commercial powerplant licensees, by regulatory bodies, and by mutual and stock insurance underwriters; it will also apply to plants under the AEC's cognizance.

Quality Assurance Criteria

In April the AEC issued for public comment and interim guidance proposed additions to its regulations establishing quality assurance requirements for the design, construction, and operation of certain reactor structures, systems, and components.[22] The requirements would apply to all activities during the lifetime of a nuclear powerplant—from design through operating phases—which affect the safety-related functions of these structures, systems, and components.

Seismic Criteria

In the program to develop criteria establishing the principal seismic and geologic considerations for determining the suitability of proposed reactor sites, the AEC held an industry advisory conference with selected utilities in Bethesda, Md., on July 8, 1969. The utilities formed an *ad hoc* working group to develop coordinated comments on the tentative criteria made available by the AEC. Work in this area has been carried on by the AEC staff with the aid of the ACRS, other Federal agencies, and consultants. Related seismic design criteria are expected to be available for public comment in 1970.

INDEMNIFICATION AND INSURANCE

The indemnification program established under the Price-Anderson Act provides financial protection to the public, AEC facility licensees, and AEC contractors by assuring that in the unlikely event of a serious nuclear accident, funds would be available for the payment of liability damages. A combination of commercial insurance and governmental indemnity amounting to a maximum of $560 million is provided to cover public liability claims that might conceivably arise from a nuclear incident. No claims have been made under the licensee indemnity agreements during the 12 years in which the program has been in existence.

[22] Proposed amendment (to 10 CFR Part 50) published in the *Federal Register* on April 17, 1969.

Indemnity Agreements in Effect

At the end of 1969 there were 97 indemnity agreements in effect with AEC licensees. These agreements cover the licensed operation of 18 power reactors, 81 research reactors, five testing reactors, 13 critical facilities, one chemical processing facility, operation of the NS *Savannah*, the storage of nuclear fuel prior to operation of a reactor at seven sites; and one construction permit.

During 1969, $300,620 was earned by the AEC in indemnity fees.[23] Fees earned since the inception of the program totaled $1,224,683.

Refunds and Increased Commercial Insurance

As a result of the excellent safety record of the nuclear industry, refunds of premium reserves were paid in 1969 to holders of nuclear liability commercial policies in 1959, by the Nuclear Energy Liability Insurance Association (NELIA) and the Mutual Atomic Energy Liability Underwriters (MAELU).

This was the third successive year in which refunds of premium reserves were made under the industry's retrospective credit rating plan which is based on loss experience over a 10-year period. Total refunds of $477,870 paid in 1969 represented 66.8 percent of the 1959 premiums paid, and 97.1 percent of the loss reserve established for the premiums.

On January 1, 1969, the two nuclear energy insurance pools increased the amount of commercially available nuclear energy liability insurance from $74 million to $82 million. The AEC regulations and the applicable agreements were amended effective February 1, 1969, to reflect this increase.

AEC MATERIALS LICENSING

The AEC's materials licensing program is principally concerned with the nuclear fuel cycle for reactors and the radioactive byproduct materials (radioisotopes) produced in nuclear reactors. Outside the expanding fuel cycle activities, the growing uses of uranium, thorium, plutonium, and radioisotopes in industry, commerce, medicine, and education and the disposal of radioactive wastes are also requiring increased regulatory effort by the AEC and those States which have entered into regulatory agreements with the AEC.

[23] The AEC charges, as required by statute, an annual indemnity fee of $30 per thermal megawatt for licensed reactors, subject to a minimum charge of $100.

Nuclear Fuel Cycle Activities

The licensing program for the steps involved in supplying fuel for nuclear power reactors includes the evaluation, from the standpoint of public health and safety, of applications for licenses to operate uranium mills, plants to chemically process uranium and plutonium, fuel fabrication plants, and facilities for recovering the unused uranium and plutonium from irradiated reactor fuel. Related research and development work, and the packaging of certain types and quantities of radioactive material for transportation also require licensing.

Fuel Fabrication

General Electric Co. was issued a broad materials license for a new uranium hexafluoride conversion and fuel fabrication plant at Wilmington, N.C. The license is similar to those issued to General Electric for its California operations at San Jose and Vallecitos in that it permits, within defined limits, latitude in making changes in plant equipment and procedures without license amendments. A similar license was issued to Westinghouse Electric Corp. for its plant at Columbia, S.C. This is the first Westinghouse plant to conduct enriched uranium hexafluoride conversion operations. Westinghouse at Cheswick, Pa., was licensed to process and fabricate plutonium and to conduct research and development work on mixed uranium-plutonium oxide fuels for fast breeder reactors. A license application to conduct similar activities was filed by Kerr-McGee Corp.

Fuel Reprocessing Plants

During the year, construction progressed on the Nation's second privately owned irradiated reactor fuel reprocessing plant. An application for a third proposed plant was under AEC review, and a preliminary site evaluation was completed for a fourth such facility.

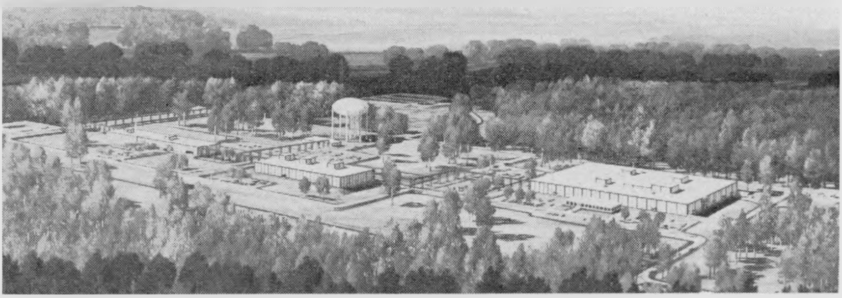
As of December 31, 1969, General Electric's Midwest Fuel Recovery Plant (MFRP) under construction near Morris, Ill., was approximately 42 percent complete. Scheduled for commercial operation in mid-1971, the MFRP is designed to process 300 metric tons a year of irradiated uranium in the form of low-enriched uranium oxide clad in stainless steel or zirconium alloy.

In April, Atlantic Richfield Co. submitted a preliminary site evaluation report as a basis for AEC review of the suitability of a proposed site, near Leeds, S.C., for a plant designed for a daily throughput of 5 metric tons of spent fuel and would provide, additionally, for recovery of neptunium. A preliminary conclusion indicates the site is suitable, subject to evaluation of more complete information yet to be provided.

Evaluation continued on a reprocessing plant proposed by Allied Chemical Corp. Designed to process up to 5 metric tons per day of low-enriched reactor fuel, the facility would be located near Barnwell, S.C., contiguous with the east boundary of AEC's Savannah River Plant site.

An application by Nuclear Fuel Services, Inc. (NFS), for a full-term operating license to supersede its provisional license, was under review at yearend. The West Valley, N.Y., fuel reprocessing plant has been operating since April 1966. AEC consent was granted in connection with the transfer of control of AEC licenses governing NFS

Two New Uranium Fuel Fabrication Plants were licensed by the AEC in 1969. both in the Southeast. *Above* is view of Westinghouse Electric Corp.'s plant at Columbia, S.C., located on a 1,115-acre site and employing 600 persons. It is the first Westinghouse plant to convert uranium hexafluoride—the gaseous form in which uranium comes from AEC enrichment facilities—into uranium dioxide powder. Operations include fabrication of special alloys into positioning grids for nuclear reactor fuel, and compaction of the powder into cylindrical fuel pellets. *Below* is architect's sketch of General Electric Co.'s new uranium hexafluoride conversion and fuel fabrication plant at Wilmington, N.C.



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operations at West Valley, N.Y., and Erwin, Tenn., from W. R. Grace and Co., to Getty Oil Co.

During the year, 39 licensing actions were taken authorizing persons to manipulate the controls of the NFS fuel reprocessing plant. A total of 168 license authorizations have been given to date to 74 personnel of this, the only operational licensed irradiated fuel reprocessing facility.

Reprocessing Plant Siting and Waste Disposal Policy

In June, the AEC published for public comment a proposed policy [24] to govern the siting of commercial fuel reprocessing plants and the disposal of high-level radioactive liquid wastes generated at these facilities. The objective is to give full consideration to public health and safety in this area while at the same time presenting minimum impediment to the growth of economic nuclear power.

Principal declarations in the proposal are that (1) public health and safety considerations associated with fuel reprocessing plants do not require their location on Federally-owned or controlled land, and (2) high-level radioactive liquid wastes produced in chemically reprocessing irradiated fuels must be converted to an AEC-approved solid form and shipped to a Federal repository for permanent disposal. Fees will be collected from industry for the disposal costs.

Under the proposed policy, time and quantity limits are set for retention of high-level liquid wastes undergoing radioactive decay at the plant site before mandatory conversion to solid form and transfer to a repository. The AEC is to develop standards identifying acceptable solid forms for safe shipment to the Federal repository, and estimated fees to be charged.

Radioisotopes Licensing

The AEC, during 1969, continued to simplify and expedite licensing procedures for the use or possession of radioisotopes, which are the subject of approximately 90 percent of atomic energy materials licenses.

In a move to improve regulatory procedures for distributing manufactured products containing radioisotopes, the AEC regulations were amended [25] to exempt from licensing requirements the receipt and use

[24] Policy statement proposed to be added to 10 CFR Part 50 published in *Federal Register*, June 3, 1969. Described in AEC public announcement M-132 of June 2, 1969.

[25] Effective and proposed amendments of AEC regulations dealing with licensing and regulation which were published in 1969 are summarized in Appendix 5.

of two classes of products: (*a*) Self-luminous products containing tritium, krypton-85, and promethium-147, and (*b*) radioisotopes contained in gas and aerosol detectors designed to protect life or property from fires and airborne hazards. Previously, it had been AEC practice to issue such exemptions only for individual products. The amendments to the regulations included general safety criteria to be met. Manufacturers of such exempt products will be specifically licensed only after having demonstrated that their products will adequately contain the radioactive material and radiation under both normal and severe conditions of handling, storage, use and disposal.

The previous exemption from licensing requirements for certain types of electron tubes was amended to include additional types of electron tubes containing tritium, cobalt-60, nickel-63, krypton-85, cesium-137, and promethium-147. The regulations include appropriate safety criteria for authorizing manufacturers to distribute electron tubes for use under the exemption.

Irradiators

Radiation Machinery Corp., Hanover, N.J., was licensed to operate a radiation processing facility using 1.5 million curies of cobalt-60 in a water-shielded irradiator, and to possess and store an additional 1 million curies of cobalt-60 or cesium-137 in two hot cells. The irradiator is used for producing a prefinished (plastic-impregnated) flooring material.[26]

Neutron Products, Inc., Dickerson, Md., was authorized to operate a prototype packaged-products irradiator at its existing 2-million-curie cobalt-60 pool-type irradiator and storage facility. A shielded irradiation cell has been built over a pit in the present facility where sources of cobalt-60 containing up to 200,000 curies can be used for irradiating packages moved in and out of the cell by an automatic conveyor system. In addition, a canal and hot cell have been added to the facility, and the processing of cobalt-60 sources for commercial distribution has been authorized.

Nuclear Materials and Equipment Corp. (NUMEC), Apollo, Pa., was authorized to increase the capacity of its pool-type irradiator from 850,000 curies of cobalt-60 to 1.5 million curies. This is the larger of the two irradiators operating at NUMEC's Quehanna facility. Irradiation of commercial products is authorized. Plastic-impregnated flooring material is presently being produced.

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[26] See "Wood Polymers" item in Chapter 10—Isotopic Radiation Applications.

Cardiac Pacemaker

Medtronic Inc., of Minneapolis, Minn., and Adcole Corp., Waltham, Mass., were licensed to conduct cardiac pacemaker development programs using plutonium-238 powered sources produced by Donald W. Douglas Laboratories, Richland, Wash.

Export of Materials

During the year, the AEC issued 228 specific export licenses authorizing the export of byproduct, source, and special nuclear material from the United States. Twenty-seven licenses were issued which permitted the export of byproduct and source material to Eastern European countries. Fifty-seven special nuclear material licenses were issued for the export of special nuclear material to 14 countries. West Germany received the largest quantity of special nuclear material (a total of 6,331 kilograms).

STATE REGULATORY AGREEMENTS

The number of States which have assumed certain regulatory functions grew to 22 in 1969 as three more States signed agreements with the AEC. The AEC-State cooperative program is authorized under section 274 of the Atomic Energy Act of 1954, which provides procedures and criteria whereby the AEC may, by formal agreement, relinquish to individual States certain of its regulatory authority over radioactive materials when the State's program is compatible with the AEC's program for regulating these materials, and is adequate to protect the public health and safety.

New Agreements

North Dakota, South Carolina, and Georgia entered into regulatory agreements with the AEC, effective on September 1, September 15, and December 15, 1969, respectively. The 22 States which have assumed regulatory authority over byproduct material, source material and less than critical quantities of special nuclear material are shown on the map.

The AEC transferred 31 licenses to North Dakota, 94 to South Carolina, and some 242 to Georgia. About 47 percent of the estimated 15,500 atomic energy materials licenses in effect in the United States are now, by agreement, under the regulatory authority of these 22 States. During the year, other States continued to prepare for the assumption of regulatory responsibility by developing the required regulatory programs.

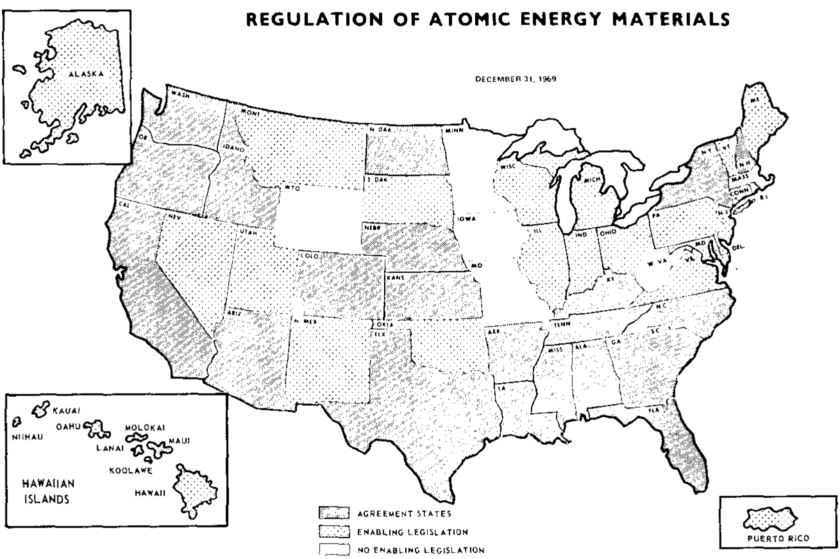
Continued Cooperation with States

Each agreement provides that the AEC and the State will use their best efforts to maintain compatible regulatory programs. To assure the continued adequacy of State regulatory programs, and to promote their continued compatibility with the AEC's program, the AEC conducts: (*a*) Periodic reviews of each State's program; (*b*) an annual meeting with the agreement States to discuss regulatory policies and practices; (*c*) the exchange of information on regulations, licensing, inspection and enforcement data; and (*d*) consultation on special regulatory problems. An annual formal review of the status of the regulatory program of each agreement State is made by the AEC; such a review was last made in May 1969 with a finding that the programs of the then 19 agreement States continued to be adequate to protect public health and safety, and were compatible with AEC's program for regulating nuclear materials.

Training for State Personnel

Health physics and radiation protection training courses are provided by the AEC to assist State staffs in developing and maintaining

STATUS OF STATE INTEREST *in* REGULATION OF ATOMIC ENERGY MATERIALS



technical competence. A 10-week course in these subjects was presented in 1969 at Oak Ridge Associated Universities. One-week training courses in the health and safety aspects of industrial radiography were presented by the AEC at the University of Alabama, the University of California at Los Angeles, the University of Denver, and Manhattan College in New York. A total of 50 State personnel, representing 25 different regulatory agencies, attended these regional courses. Two orientation courses in regulatory and licensing policies and procedures, with participation of 18 persons from 16 different States, were provided State regulatory personnel at the AEC's Bethesda, Md., office.

Transfer of Products

The AEC amended its regulations in 1969 to redefine the basis of continued AEC regulatory authority within the agreement States over the transfer by the manufacturer of products containing byproduct or source material whose subsequent possession, use, transfer, and disposal are exempted from AEC licensing and regulatory requirements. The changes confine AEC regulation over the transfer of exempt products to product specifications and quality control; the States regulate any radiation hazards that might arise during manufacture of such products.

COMPLIANCE AND ENFORCEMENT

During 1969, AEC personnel performed 1,580 inspections of activities conducted under materials licenses and 706 inspections of reactor facilities. In three percent of the inspections of materials licenses and six percent of the inspections of operating reactors, the AEC inspectors found items of noncompliance with regulatory requirements that required formal AEC enforcement action.[27]

Safety in Atomic Energy Industry

The fourth annual Bureau of Labor Statistics survey of injury frequency and severity rates of the atomic energy industry, covering data for the year 1968, again showed its work-injury experience to be better than recent averages for all manufacturing industries. In 1968,

[27] AEC regulations (10 CFR Part 2.200) provide for enforcement actions in the form of issuance to licensees of notices of violations and orders to modify, suspend, or revoke a license.

atomic energy employees experienced an injury frequency rate of 6.7 injuries from all causes for each million man-hours worked and an injury severity rate of 520 days lost for each million man-hours worked. By comparison, the rates for all manufacturing were 14.0 injuries and 709 days for each million man-hours worked.

Radiation Exposure Statistics

The AEC continued to obtain information on radiation exposures to licensee employees below those levels that must be reported by regulation. Through contracts with three leading film badge companies,[28] the AEC received calendar year 1968 summaries on film badge readings of licensee-employees using the services of the companies. The data covered about 30 percent of AEC licensees and about 55,000 of their employees. Very low levels of exposure were generally indicated. The badges of 95 percent of the employees showed an exposure of less than 1 rem [29] during 1968, and the badges of 73 percent of all employees showed an exposure of less than 0.1 rem for that year.

Radiation Incidents

During the year, nine radiation incidents, seven of which involved personnel exposures, were reported by AEC licensees as required by the regulations.[30] AEC personnel investigated each incident to determine its cause, extent of radiation exposure to persons, adequacy of licensee efforts to prevent recurrence, and the need for licensing or enforcement action.

In one incident, several hospital employees and repairmen received exposures because of faulty operation of the head shutter mechanism of a teletherapy machine containing a nominal 2,000-curie cobalt-60 source. The highest exposures were estimated to be about 4,000 rems, to the hands of three technicians. The highest whole-body exposure, to a hospital employee, was estimated at about 25 rems.

Of the remaining eight incidents, six occurred during radiographic testing (nondestructive testing or inspection) operations. The maximum exposure was about 515 rems to the hand of a radiographer. The highest whole-body exposure was 31 rems, also to a radiographer. Failure to properly retract the radioactive source into the shield and

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[28] See p. 143, "Annual Report to Congress for 1967."

[29] Rem stands for roentgen equivalent man—a measure of the dose of ionizing radiation to body tissues, roughly equal to a dose of 1 roentgen of high voltage X-rays.

[30] Licensees are required to report all significant radiation incidents to the AEC. These reports are available for inspection in the AEC's Public Document Room, 1717 H Street NW., Washington, D.C. See footnote on p. 302, "Annual Report to Congress for 1965."

the operator's failure to make adequate radiation surveys led to most exposures. Two other incidents involved the spread of plutonium contamination, resulting in temporary loss of facility use. There were no releases to uncontrolled areas or personnel exposures in these two occurrences.

Lost Radioactive Material

AEC licensees reported 31 losses of radioactive material during 1969. In 16 of the instances, the missing material was subsequently recovered with no apparent radiation hazard to the public. In those instances where the material was not recovered, six losses occurred in inaccessible locations, and six were losses of small quantities of radionuclides. None of these losses constituted a hazard to the general public. Of the three remaining instances, two involved 100-millicurie strontium-90 medical treatment sources, one of which was stolen, the other lost in shipment, and the third involved the theft of two small plutonium-239 sources. These three cases were turned over to other Federal agencies for further investigation. Each source was in a container designed to protect against radiation during handling, and which bore a label indicating the radioactive contents.

Chapter 7

OPERATIONAL AND PUBLIC SAFETY

HAZARDS PROTECTION

The AEC experienced its largest single property loss on May 11, 1969, when a multimillion-dollar fire occurred at the Rocky Flats Plant, Boulder, Colo., during nonworking hours; it was fought only by employees of the operating contractor (see Chapter 3—"The Nuclear Defense Effort"). One employee received an internal exposure to plutonium but responded well to treatment. Following the fire, the AEC and its contractors reexamined all major fire risks and increased the fire protection alertness throughout the AEC. In addition, two outside consultant companies (Factory Insurance Association, and Factory Mutual Research Corp.) are being used to assist the AEC in identifying existing fire protection weaknesses. The initial phase of the consultants' reviews is covering all of AEC's major weapon sites and began at the Rocky Flats Plant. The lessons learned from the fire and the recommendations from the survey will be used by the AEC to augment its continual preplanning for emergencies.

EMERGENCY PREPLANNING

Emergency Plans for AEC Facilities

Additional guidance has been developed for further improvement and refinement of emergency plans for AEC facilities. This guidance resulted from studying the extent of preplanning undertaken by AEC contractors to cope with emergencies involving radioactivity. The review of the AEC's emergency plans for handling accidents involving radioactivity was the most extensive study of this type that has been undertaken by any country. The resulting information and guidance have been incorporated into the efforts of three United Nations affiliated agencies—World Health Organization, International Atomic Energy Agency (IAEA), and the Food and Agriculture Organization—to develop international standards identifying the requirements for, and the necessary characteristics of, formal plans to cope with emergencies involving radioactivity. A manual sponsored by these agencies, "Planning for the Handling of Radiation Accidents," is being published [1] by the IAEA.

Medical Planning and Care in Radiation Accidents

The AEC considers it prudent to initiate programs for preparedness for the care and treatment of radiation accident patients as the nuclear industry continues its rapid expansion. Following a broad (1967) survey of radiation emergency preparedness in the AEC Federal and licensee programs, the AEC initiated a training and orientation program for medical and paramedical [2] personnel to develop the levels of understanding requisite to future needs.

One key element in the AEC program is a series of postgraduate-level seminars for physicians, initiated in 1969, on medical planning and care in radiation accidents. Five 3-day seminars have been held (in Richland, Brookhaven, and Oak Ridge), each with 30 to 40 participants who were selected on the general basis of affiliation with AEC licensee programs, universities, community hospitals, or public-health departments. A continuing program is planned to keep these physicians up-to-date on knowledge in this specialized area.

On a few occasions, persons have needlessly been refused admission to hospitals because of fear related to radioactive contamination. Because of this, the AEC has recognized the need for training and the orientation of all persons who deal with radiation accident patients, such as rescue squad members, physicians (especially those who staff emergency rooms), nurses, hospital administrators, and attendants. The American Medical Association (AMA), the American Hospital Association (AHA), and the American Public Health Association (APHA) have cooperated with the AEC in solving this problem.

The first step was the production of an AEC training film [3] in cooperation with the professional associations. The film presents the general types of radiation-accident patients likely to be encountered

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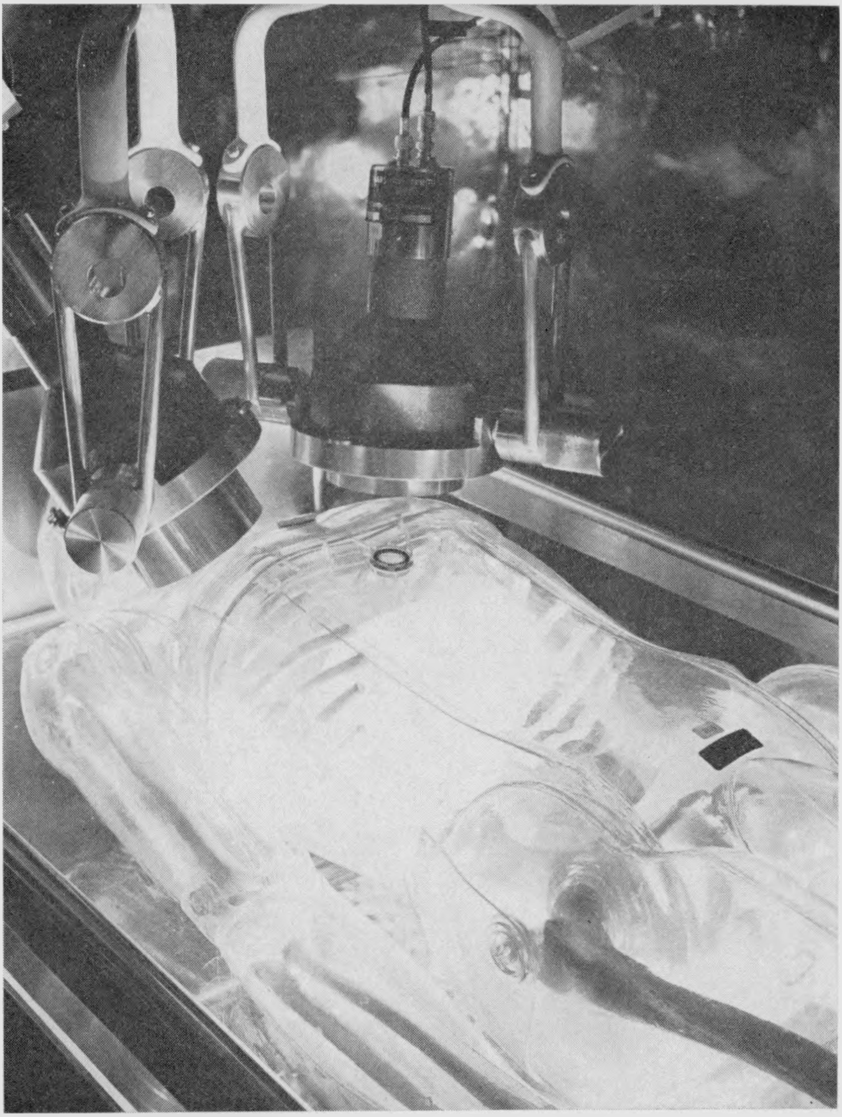
[1] Available from the National Agency for International Publications, Inc., 317 East 34th St., New York, N.Y. 10016.

[2] Personnel trained to supplement the work of regular medical staffs.

[3] Film entitled "Radiation Accident Patients—Emergency Handling for Hospitals and Rescue Squads." Copies available for loan to professional level groups through AEC film libraries, or write: Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.



"Sam, the Phantom," Mound Laboratory's body counting facility for locating and counting possible deposits of plutonium-238 in radiation workers, was completed in 1969. The calibration device is a plastic, man-sized model containing a human skeleton. "Sam" can be supplied with simulated lungs or liver containing known amounts of radioisotope for calibrating the sensitive radiation counters, shown at *top* of photo. The counting facility is part of a health physics program designed to ensure the safety of radiation workers at Mound Laboratory as a part of the AEC's preplanning program so that its contractors can cope with emergencies involving radioactivity.

and the proper principles and methods for handling, receiving, and initially caring for such patients. During 1969, the film was shown at the annual conventions of each of the sponsoring professional associations, as well as at four international meetings: International Rescue Squad Association, International Association of Chiefs of Police (IACP), International Congress of Occupational Health, and the IAEA.

The second step was the development of an exhibit, shown at national and local meetings of the AMA, AHA, and APHA to describe, in graphic form, the main points of the training film. The third step was to prepare brochures,[4] sponsored jointly by the AEC and the national organizations (AMA, AHA, APHA, and IACP), to accompany the exhibit and the film. The brochures are written expressly to provide, as reference material, appropriate instructions to hospital administrators, physicians, nurses, rescue squad and ambulance and police personnel. Included in the brochures are procedures for receiving and handling radiation accident patients, and addresses of the AEC's regional radiological emergency assistance offices where immediate help may be obtained.

Radiological Assistance Program

During 1969, the AEC acted on 62 requests for radiological emergency assistance; 36 of these required the dispatch of assistance to the scene. A total of 760 requests were handled by the AEC during the 10-year period 1960–1969, inclusive. In 371 of these, radiological assistance was dispatched to the scene.

Because of the current trend toward increased involvement of local, as well as State, emergency service organizations when incidents involving radioactivity occur, a special effort is being made to make more information on radiological emergency operations available to local police and rescue squads. As an initial step, AEC provided information on the AEC's Radiological Assistance Program and guidance on local radiological emergency actions to 7,028 members of the International Association of Chiefs of Police. In addition to other technical procedural, and planning information, the AEC's Radiological Emergency Operations Instructor's Manual (TID–24918) [5] and Student's Manual (TID–24919),[5] released for sale to the public in May 1969, are available for use in police training courses.

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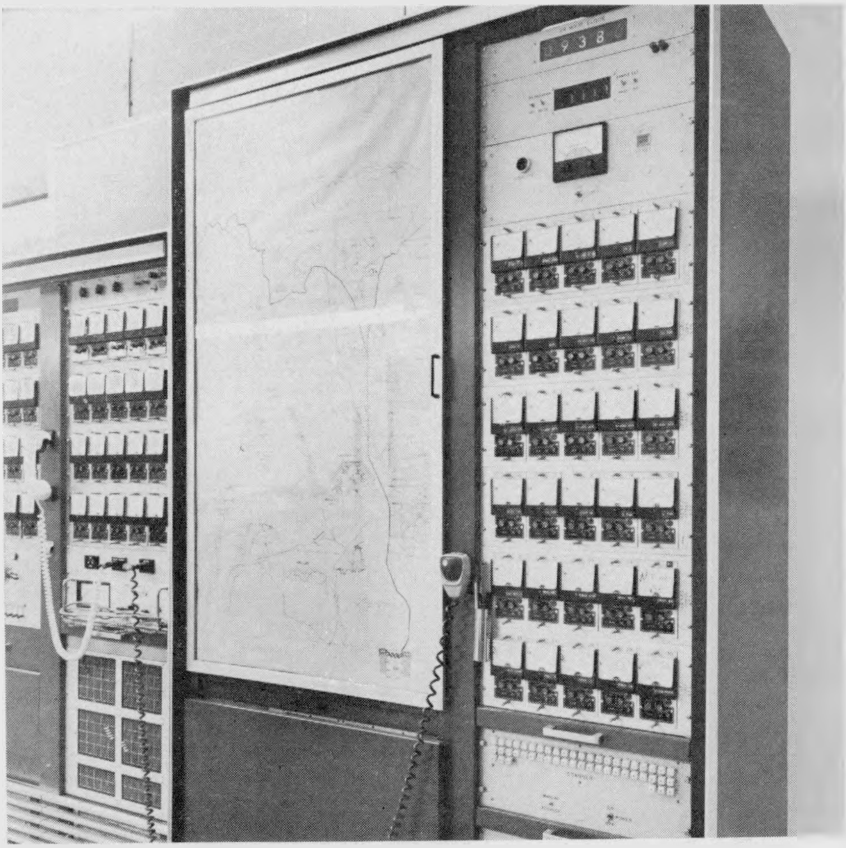
[4] Available from Division of Operational Safety, U.S. Atomic Energy Commission, Washington, D.C. 20545.

[5] Available from the Clearinghouse for Federal Scientific and Technical Information Springfield, Va. 22151, for $3.00 a copy.

OPERATIONS ACTIVITIES

Data collected from AEC installations, or as the result of special research efforts, are summarized regularly in *Radiological Health Data and Reports*, a monthly publication of the U.S. Public Health Service (USPHS).[6] During 1969, radioactivity levels detected in areas

[6] Available from Superintendent of Documents, U.S. Government Printing Office. Washington, D.C. 20402. Subscription price—$5.00 per year; $1.50 additional for foreign mailing; single copy, $0.50.



Simplification in Monitoring radiation levels at the Nevada Test Site was brought about through the use of an automatic gamma detection system which monitors the test site around the clock. The 30 permanent telemetry stations, developed by Reynolds Electrical and Engineering Co., are located within a 20-mile radius of the control point and are connected by hardwire to a central console and measure the radiation levels at their respective locations. The values are then transmitted to readout meters located at the central console (shown in photo), where there is a sophisticated alarm system to alert operating personnel.

around nuclear facilities were below AEC radiation protection standards and less than the Federal Radiation Council (FRC) radiation guidelines.

Offsite radiological monitoring around the Nevada Test Site (NTS), including the Nuclear Rocket Development Station (NRDS), and other test areas (Central Nevada, Amchitka Island, and at Plowshare program experiments), is conducted for the AEC by the USPHS. A summary of the data collected is published in *Radiological Health Data and Reports*. Only one routine film and thermoluminescent detector station in the unpopulated area of Queen City Summit, Nev., detected an exposure slightly over normal background during the first half of 1969. This exposure was due to residual activity from Schooner, a Plowshare program cratering experiment conducted on December 8, 1968.[7] After March 4, 1969, the readings in this area returned to background.

During the July 1–December 31 period detectable levels of radioactivity were observed in a nearby offsite area following the Pod event October 29. A gamma radiation level of about twice the natural background (0.02 mr./hr.), of short duration, was observed at Lathrop Wells, Nev. The radioactivity posed no health problems to the offsite population.

Joint Survey of Radioactive Shipments

The Department of Transportation, the Department of Health, Education, and Welfare, and the AEC are conducting a study to evaluate the potential radiation exposure to people and property in the transportation environment. The major objectives of the study are to: (*a*) Gather, from packages of radioactive materials, factual information and data concerning radiation levels in transport; (*b*) obtain information on compliance, by shippers and carriers, with the regulations for transport of radioactive materials; and (*c*) evaluate the effectiveness of the transportation regulations with regard to general public safety and that of transportation workers.

Sites included in the survey were Knoxville, Tenn.; Washington, D.C.; Boston; New York; Newark, N.J.; and Chicago.

AEC EXPERIENCE

AEC Accidents and Property Damage

Five fatalities occurred in 1969, two resulting from falls, two from electric shock, and one from being hit by a falling pipe. The total

[7] See pp. 198, "Annual Report to Congress for 1968."

damage to AEC property during 1969 (exclusive of the $45 million fire at the Rocky Flats plant: see Chapter 3) was $5,563,031 until late December, when high explosives detonated during normal remote-controlled pressing operations at the Pantex Plant (Amarillo, Tex.). There were no injuries to personnel and no radioactive materials were involved. At yearend, the cause of the estimated $200,000 December 26 accident had not been determined. The greatest monetary loss, other than the Rocky Flats and Pantex incidents, was a $67,900 fire in an electronics maintenance trailer at Kirtland Air Force Base near Albuquerque, N. Mex.

Radiation Exposures

An AEC contractor employee inadvertently received a radiation exposure while working with an X-ray diffraction machine. Based on physical measurements and reconstruction of the incident, the employee's exposure from a narrow beam of soft (8 kev.) X-rays to fingers of the left hand was estimated to be 1,700 *rem;* there was no permanent injury or loss of time from work. Four lesser radiation exposures occurred, one whole-body and three internal.

Safety of AEC-Owned Reactors

During 1969, 26 AEC contractors had operational control over 76 stationary reactors, one nuclear rocket propulsion engine test stand and one associated reactor test cell, and 33 critical facility cells, all of which are owned by the AEC. About 1,500 individual reactor personnel were involved in the operation of these facilities. At the end of the year, there were two AEC reactors under construction and two in planning.

The AEC headquarters and field safety staffs, with a combined nuclear experience in excess of 500 years, devoted approximately 42 man-years of effort during 1969 to functions aimed directly at assuring safe operation of AEC facilities. These efforts, along with those of the operating contractors, have resulted in 12 months of operations that have been free of any reactor-caused injuries to AEC contractor personnel or to the general public, and free of any significant releases of radioactivity to the environment.

Chapter 8

SPACE NUCLEAR PROPULSION

NUCLEAR ROCKET PROGRAM

The nuclear rocket program, a joint endeavor of the National Aeronautics and Space Administration (NASA) and the AEC, is aimed at providing a significant increase in propulsion capability for future space activities. Principal objectives of the program are to provide the basic technology for nuclear propulsion systems, and to develop a 75,000-pound thrust flight engine called NERVA[1] based on this technology. The program also includes supporting advanced research and technology activities in which the aims are to provide for the continued improvement of engine performance and to provide basic know-how for the development of a nuclear stage.

The NERVA engine now under development in the nuclear rocket program achieves its thrust by heating hydrogen to temperatures in the 4,000° F. range and expanding this hot gas through a nozzle to provide propulsive thrust. The tremendous heat required to achieve this temperature is supplied by a nuclear reactor, a cylindrically-shaped unit approximately 3 feet in diameter and 5 feet long.

NERVA DEVELOPMENT PROGRESS

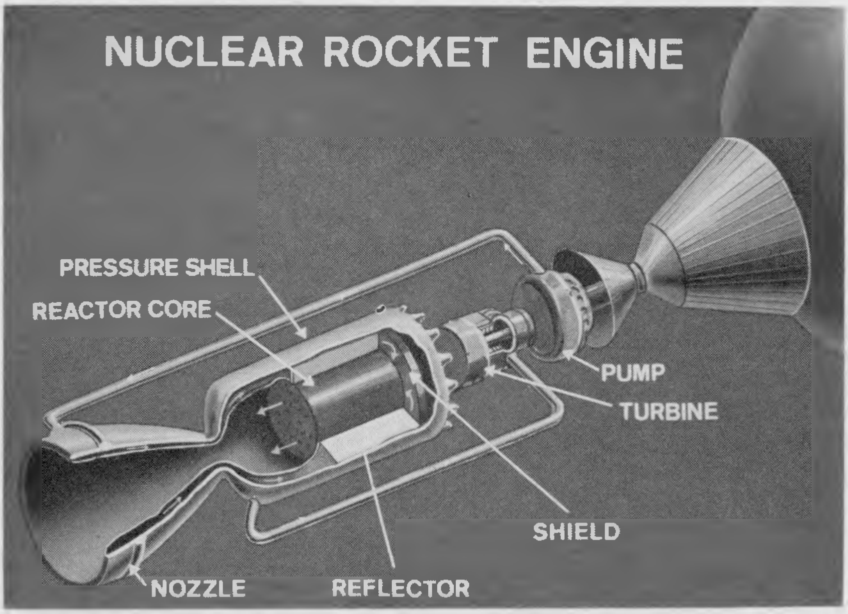
Fundamentally, the NERVA development program has benefited from the results of the Kiwi,[2] Phoebus, and NERVA technology efforts. This work has provided a preliminary assessment of the more obvious requirements of a nuclear propulsion system. Among these

[1] NERVA is an acronym for Nuclear Engine for Rocket Vehicle Application.

[2] The first series of nuclear propulsion test reactors (1959–1964) were named after the tailless, hairy feathered New Zealand bird which cannot fly; besides achieving an operating time of 8 minutes and a power over 1,000 thermal megawatts, the Kiwi series showed that the reactor engine could be restarted. The Phoebus series (1965–1968) continued the advancement toward the NERVA goal; reactor levels above 4,000 megawatts were achieved.

are rapid startup, shielding, liquid-hydrogen propellant, high power density, reactor lifetime, and self-energized start.

There are many specific requirements which apply to a propulsion system linked to a flight vehicle with a given mission. Through the systems-engineering approach, the functions of a given mission are analyzed and reduced to requirements for the systems involved (*e.g.* each stage of the vehicle, the propulsion systems of each, and the launch facilities needed). Mission analyses have been conducted and a preliminary evaluation of engine requirements has been made. Based on these requirements and test results, preliminary systems specifications have been prepared and work has started on the detailed design of the engine by the industrial contractor team of Aerojet-General Corp. (Sacramento, Calif.), and Westinghouse Electric Corp. (Pitts-



In A Typical Nuclear Rocket Engine, as now under development by the AEC and NASA, the flow of hydrogen necessary to produce thrust starts from the propellant tank shown at the *right* in the sketch. This hydrogen is stored in liquid form in the tank, at a temperature of approximately −420° F. From the tank, the hydrogen is pumped through the engine by the turbopump. As indicated by the *arrows*, the flow proceeds through the nozzle shell, the reactor neutron reflector, through the uranium-fueled reactor core, where it is heated to approximately 4,000° F., and out of the nozzle to produce engine thrust. During engine operation, the hydrogen flowing through the nozzle wall and reflector is used as a coolant to keep the temperature of these components at a safe level. The reactor will be about the size of an office desk.

burgh, Pa.). Alternative component and subsystem conceptual designs have also been evaluated to allow rational design selections to be made in light of the requirements. NASA's Marshall Space Flight Center (Huntsville, Ala.), Kennedy Space Center (Florida), Lewis Research Center (Cleveland, Ohio), and contractors work closely with the AEC to insure that the requirements and design choices are reasonable and justified.

Progress in NERVA Technology

The last activity to be completed in the NERVA technology phase of the nuclear rocket program was the ground-experimental engine (XE) test program at the Nuclear Rocket Development Station in Nevada.[3] This program, started in the fall of 1968, was successfully completed in August 1969. All NERVA effort is now being applied to the development of the 75,000-pound thrust NERVA engine for flight applications. The primary objectives of the XE test program were to investigate: (*a*) The operational features of the various systems of the engine test facility (Engine Test Stand No. 1); (*b*) the performance of the engine and the test facility during engine startup; (*c*) the various modes of engine control; and (*d*) engine performance data at various power levels.

The XE engine had been installed in the test stand during October 1968, and prepower and other preliminary activities were concluded by early December. However, predictions of possible abnormally high ground motion from an underground nuclear weapons test at the nearby Nevada Test Site caused power runs of the engine to be delayed until these tests were completed.

Power tests on the XE engine involving the flow of propellant (liquid hydrogen) began on March 20 and ended on August 28, 1969. During this period, 28 successful engine startups were completed under simulated altitude conditions. The engine was operated for a cumulative test time of approximately 3.8 hours at various thrust levels, including 3.5 minutes at full thrust (approximately 55,000 pounds).

Detailed analyses of test data will provide significant information on NERVA engine development. This results from the similarities in the XE and NERVA engine hardware, and because the development testing of NERVA engines will be accomplished in the same engine test stand (with some modifications). Operating modes and control system designs for NERVA also will be an outgrowth of the XE engine investigations.

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[3] See p. 158, "Annual Report to Congress for 1968."

ADVANCED RESEARCH AND TECHNOLOGY

A continuing objective of fuel element research in the nuclear rocket program has been to extend the performance capability of nuclear rocket reactors through the improvement of the reactor fuel elements. Every gain made in fuel element operating temperature, duration, and recycling capability is directly transferrable into meaningful gains in space vehicle performance. The fuel element materials research work has been enhanced through the development of the Pewee reactor [4] by Los Alamos Scientific Laboratory. This small-size reactor uses only a few fuel elements and overcomes the disadvantages of electrically heated furnaces in the fuel development work.

Fuel Element Materials Research

The principal deleterious effect of reactor operation on a fuel element is the progressive weight-loss and resulting damage caused by the corrosion of the fuel element graphite by hot hydrogen; the higher the temperature, the more severe the corrosion problem.

The program for improving fuel element performance comprises principally the development of improved corrosion resistant coatings for fuel elements and the investigation of improved matrix materials that show promise of reducing the corrosion. Other objectives are to gain a better understanding of the mechanism of corrosion attack, coating technology, coating processes, and improved means of assessing coating integrity.

During 1969, work continued on the development of fuel materials of the carbide-composite type and other advanced fuel materials. These materials are believed to have a very high temperature capability.

Fuel Element Testing

Fuel fabricated from these materials will be tested in a second Pewee reactor, the Pewee–2, now being readied for testing after mid-1970. The Pewee–2 will be operated in a number of approximately 10-minute, full-power cycles separated by short holds at low power. As many as six cycles may be run. Additional Pewee reactor tests will follow the Pewee–2 to demonstrate fuel concepts for achieving even higher performance.

In past years, electrical resistance tests have been used for fuel element development and quality assurance testing. As fuel element temperatures have pushed to higher and higher levels, the electrical

[4] See pp. 160–161, "Annual Report to Congress for 1968."

resistance tests have become less and less satisfactory. To overcome this difficulty, Los Alamos has designed a reactor concept, called the "nuclear furnace," which will test 50 fuel elements at a time and have the capability of a short turn-around-time between tests. This device is expected to replace, at least in part, the electrical tests in the fuel element development sequence. While it will *not* eliminate the need for Pewee-type tests, it will reduce the frequency of testing Pewee reactors as well as improving the yield of information from Pewee tests because of superior prior knowledge.

Chapter 9

SPECIALIZED NUCLEAR POWER

SPACE NUCLEAR ENERGY USES

Man's use of nuclear energy during 1969 involved placement on the moon of devices that used the decay heat from isotopes to provide warmth for scientific instruments (Apollo 11) and also a unit to generate electric power (Apollo 12).

Development of nuclear power for spacecraft during 1969 included continuation of work on the system technology that will be required in future missions, as well as on several operational systems for current national space program missions. Two SNAP–19 [1] generators launched during mid-April aboard the Nimbus III weather satellite have been supplying power continuously since launch. In July the Apollo 11 crew left two small heat-only plutonium-238 sources on the moon to help the seismic instruments survive the extreme cold of the lunar night. The Apollo Lunar Surface Experiments Package (ALSEP) deployed on the lunar surface by the Apollo 12 astronauts on November 19, 1969, had as the sole power source a SNAP–27 isotopic generator.

Work has begun on the National Aeronautics and Space Administration (NASA) request that the AEC develop isotopic generators for the Jupiter probe missions ("Pioneer") to be launched in 1972 and 1973, and the Mars landing ("Viking") packages to be launched in 1975. In December, NASA also requested that radioisotope heaters be supplied for the Pioneer missions. At higher power levels, nuclear reactors are the only systems that can provide the necessary power for the manned space base. Concerted efforts are being taken toward the development of a 25-kilowatt zirconium hydride system for possible use on the manned space station planned for the mid-1970's.

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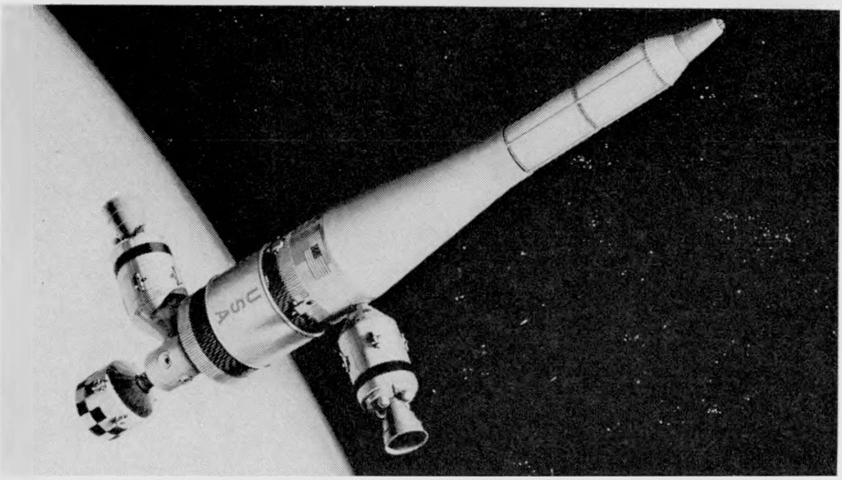
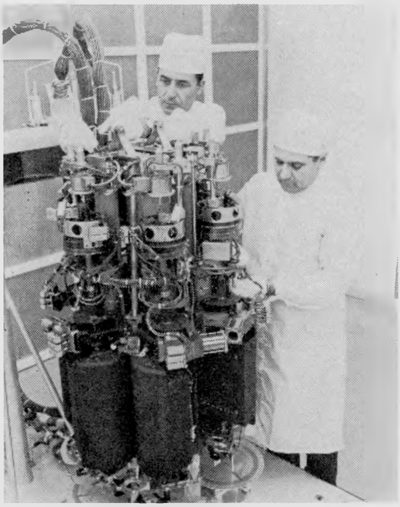
[1] SNAP—*An acronym for Systems for Nuclear Auxiliary Power.*

SPACE ELECTRIC POWER TECHNOLOGY

With the approach of the "post-Apollo" era, the importance of the role played by nuclear power has been increasing. The planetary exploration program now includes missions to Mars and Jupiter on



A Reactor-Powered Space Station of the future is shown in the *above* Atomics International (AI) sketch. The zironium hydride reactor may provide electrical power for one of the two alternative national space stations of the current NASA design studies. In this illustration, the reactor, at the narrow tapered (*upper right*) end of the station, provides heat for a 25-electrical-kilowatt thermoelectric power system. Astronauts would work and live in the bottom third of the craft, approximately between the docking points of the two Apollo-type transport spacecraft Attached to the bottom of the space station is a planned unmanned research satellite. In photo at *left*, technicians at Canoga Park, Calif., inspect the 1,000-kilowatt S8DR compact nuclear reactor built by AI for the AEC. This versatile type of reactor could furnish electrical power for an orbiting space station, for bases on the moon, or in remote areas of the earth. The second-generation zirconium hydride reactor was operated for 6,680 hours before being shut down in December 1969 for post-test disassembly and analysis that will lead to design of a 25-kw. unit.



which nuclear power will provide significantly increased performance. For missions to the outer planets expected to be launched in the 70's, nuclear power will be indispensable because of the sparsity of sunlight available for solar array power systems at such great distances from the sun. Unmanned landings on the moon and the planets (especially Mars) will also need nuclear power in order to operate during the long, cold periods of darkness, and to survive the harshness and the uncertainties of the landings and the surface conditions. If earth satellites are to be shielded against radiation and the effects of nuclear weapons in outer space, nuclear power systems become prime candidates because of their inherent invulnerability to radiation effects. At higher power levels, the uranium-zirconium hydride reactor power system is one of the prime power concepts being considered for the national space stations of the 70's. The power level of this station is expected to be in the tens of kilowatts power level. At this level, reactors tend to become more advantageous than the large solar array-battery systems required. In the more distant future, power supplies for large space stations, lunar bases, and for manned electric propulsion systems will need large reactor power systems.

The national space program is now entering a phase in which nuclear systems offer either significant advantages or, in some cases, the only possible design selection. The task of the AEC-NASA space electric power program is to provide the long-lead-time technology needed to allow designers to select and use nuclear power systems with confidence for future missions, as well as to develop, qualify, and deliver the nuclear power systems requested by users for specific missions. Due to limited resources available, the work during 1969 met only the most critical space program technology needs and these only in a limited way. Column 3 in Table 1 shows where current emphasis is being placed. Development of the Transit generator was started during 1969. In the 100 to 1,000-watt area, design studies of the multi-hundred-watt module are being conducted; however, much more work in this category is needed in order to meet the needs of the early-to-mid-70's. In the 1 to 10-kilowatt region, for the missions which would require use of long-life radioisotope generators, the AEC has been requested by NASA to furnish 25 thermal kilowatts of plutonium-238 fueled capsules for ground test of a multikilowatt isotope Brayton[2] cycle system in 1972. During the year, the initial plutonium heat source development work was accomplished. The 1- to 10-kw. systems that might use a reactor will continue to

[2] *Brayton* cycle—A nonconducting gas serves as the working "fluid" in a gas turbine system where the gas is heated and cooled in successive passes through the system. (See also first footnote under Table 1.)

rely on the higher power zirconium hydride (ZrH) reactor-thermoelectric[3] program to provide the technology. The zirconium hydride reactor program is being aimed primarily at the 10 to 100-kw. range. For the highest power levels shown in table 1, only the limited thermionic reactor fuel element technology and system studies work is underway.

Reactors for Space

Zirconium Hydride Reactor

Testing of the second generation uranium-zirconium hydride reactor (S8DR) continued at Santa Susana, Calif., by Atomics International (AI). Testing of this reactor began in 1968 and automatic startup was demonstrated, along with 500 hours of operation at 1,000 kilowatts in early 1969. The reactor was then operated in an endurance test at 600 thermal kilowatts for 6,680 hours. Test data collected during this operation indicate that cracking of some fuel elements occurred. Continued operation was possible at reduced but useful temperatures, but in order to preserve evidence with which to identify the

[3] *Thermoelectric (TE)*—If two dissimilar metallic materials are joined together at both ends in an electrical circuit, an electrical current will flow around the loop if one of the junctions is kept hotter than the other. Such a generator is called a "thermoelectric (or TE) generator," which may be made up of one or many such "thermocouples."

TABLE 1.—CATEGORIES OF NUCLEAR SYSTEMS AND TECHNOLOGY

Category	System characteristics	Current program emphasis
0 100 watts	Self-contained isotope thermo-electric (TE).	Navigational satellite (Transit).
100-1,000 watts	Modular isotope (TE)	
a. Short life, 2-5 mos	Short half-life	No work in progress.
b. Long life	Reusable fuel and/or higher efficiency power conversion.	Capsule and fuel technology and system studies.
1-10 kilowatts		
a. Recoverable fuel	Modular, reusable isotopes and high-efficiency power conversion.	Isotope Brayton capsules.
b. Unrecovered fuel, unmanned.	Partly shielded reactor	No work in progress.
10-100 kilowatts	Reactor-TE, 10-35-kw.; Rankine[1] reactor, 35-100-kw.	Zirconium hydride (Zrh) reactor and compact thermoelectric converter.
100 kilowatts and above	Thermionic[2] reactor or Rankine reactor.	Unit cell and fuel element and associated studies.

[1] *Rankine*—The Rankine power conversion cycle is a method of converting heat to mechanical energy using a two-phase (boiling and condensing) working fluid cycle. For space power systems, the reactor coolant liquid takes heat from the reactor core and conveys it to a heat-exchange boiler where the liquid-metal in the Rankine loop is converted to vapor. The vapor drives a turbine, which is linked to an electric generator, and then passes through a radiator-cooled condenser where it is condensed back to liquid which, in turn, is pumped back into the boiler. It differs from the Brayton cycle in that it uses a fluid rather than a gas in the cycle.

[2] *Thermionic*—By subjecting a selected metallic or semimetallic cathode material to very high temperatures, electrons are boiled off the emitter and are collected on a collector surface. This flow of electrons is a flow of electricity; generation of the electricity may take place within the reactor core.

cause of the cladding cracks, the S8DR was shut down in December 1969 after 6,680-hour operational run, and disassembly was started. The core will undergo post-test analysis to determine the design changes to be incorporated in the technology readiness program for a 25-electrical kilowatt, 20,000-hour ground demonstration of the reactor/thermoelectric system that is planned to start in 1973.

The technology readiness system design is based on the power system defined in the study by Atomics International and NASA's Marshall Space Flight Center (Huntsville, Ala.), during 1968 and early 1969 for manned space station applications. It uses the uranium-zirconium hydride reactor and the "compact" thermoelectric converter being developed for the AEC by the Westinghouse Astronuclear Laboratory (Pittsburgh, Pa.). This reactor, with the thermoelectric converter or with dynamic conversion systems, was selected for further investigation as one of the prime power sources in the definition studies of the proposed space station/base currently being conducted under contract to NASA's Manned Spacecraft Center (Houston, Tex.) and Marshall Space Flight Center.

Thermionic Reactor

The in-core thermionic [4] reactor program continued to emphasize the development of fuel elements capable of long-endurance operation at emitter temperatures around 3,000° F., leading toward a demonstration of a power-producing experimental reactor core during the mid-1970's. A prototype, single-diode fuel element was operated in a reactor core for more than 5,000 hours. Reactor and fuel element development is being conducted by Gulf General Atomic (San Diego, Calif.), and the General Electric Co. (near Pleasanton, Calif.). Supporting technology is being carried out at the AEC's Los Alamos Scientific Laboratory, Thermo Electron Corp. (Waltham, Mass.), and RCA Corp. (Lancaster, Pa.).

During 1969, the design concept for the first ground-based reactor experiment was chosen. This concept, employing the so-called "flashlight" assembly of diodes consists of a matrix of tubular fuel elements, each containing a number of small thermionic diodes connected in series, much like batteries in a flashlight.

Isotopic Power Systems for Space

Various combinations of radioisotopes, heat sources, and electrical generator concepts may be used for space electric power systems. In the present concepts, various chemical forms of plutonium-238 (half-life, 87 years) and curium-244 (half-life, about 18 years) are of major

[4] See second footnote under Table 1.

interest for long-lived systems, and other isotopes are under consideration for future, short-lived systems. However, the effort on polonium-210 was discontinued during 1969 because of budget priorities. Electricity is generated by thermocouples, with thermionics and a noble gas-driven turbine-alternator foreseen as advanced developmental concepts. Table 2 summarizes the isotope systems developed for space system use.

TABLE 2.—SNAP ISOTOPIC POWER SYSTEMS FOR SPACE

Designation (SNAP No.)	Prime contractor	Net electric power (watts)	Application	Fuel [1]	Status
3	Martin-Marietta Co.	2.7	Navigational satellites (DOD).	Pu^{238}	First unit, launched in June 1961, is still operating in orbit, quantitative performance data not available.
9A	Martin-Marietta Co.	25	Navigational satellites (DOD).	Pu^{238}	Units launched in September and December 1963 are still operating but at a lower power level; satellites inoperative.
11	Martin-Marietta Co.	25	Moon probe (NASA) (not used because 90-day NASA mission never approved for launch).	Cm^{242}	First fueling of a generator with curium-242 accomplished in July 1966. In October 1966, fueled unit completed 90-day test under simulated lunar conditions.
19	Isotopes, Inc.[2]	25	Nimbus-III weather satellite (NASA) (One, 2-module 50-watt system per satellite).	Pu^{238}	Launched April 1969; now in operation in orbit and providing power to the satellite.
27	General Elec. Co.	63	Apollo Lunar Surface Experiments Package (ALSEP) power for experiments placed on the moon by Apollo astronauts.	Pu^{238}	Five SNAP-27 generators delivered to NASA in 1968; first unit deployed with ALSEP by Apollo 12, on November 19, 1969. ALSEP immediately began successful transmission of data.
29	Isotopes, Inc.[2]	200-1,000	Possible manned and unmanned space applications (DOD & NASA).	Po^{210}	Partially successful 400-watt ground test completed 1969; development discontinued due to budgetary priorities.
Radioisotope (Brayton).	(Not yet selected)	5,500	Manned space mission	Pu^{238}	AEC will develop heat sources; NASA the Brayton cycle conversion system; fuel capsule development and testing underway.
Transit Generator.	TRW Systems.	30	Navy navigational satellites.	Pu^{238}	Detailed design and development for higher powered unit initiated.
Pioneer Generator.	Isotopes, Inc.[2]	120	NASA Jupiter probes 1972–1973.	Pu^{238}	Qualification of modified SNAP-19 underway.
Viking Generator.	Isotopes, Inc.[2]	60	NASA 1973 Mars landers	Pu^{238}	Qualification of modified SNAP-19 underway.

[1] Plutonium (Pu), curium (Cm), and polonium (Po).
[2] Isotopes, Inc. purchased Martin-Marietta's Nuclear Div. at Middle River (near Baltimore), Md., in August 1968.

SNAP–3 in Ninth Year

On June 29, 1969, a SNAP–3 unit—the first such isotopic generator to be orbited—entered its ninth year of operation in space, more than 3 years beyond its 5-year life expectancy. From ground tests of similar devices, it is known that the unit is operating at a reduced power level, although data on exact level of performance in the satellite are not available. This radioisotope thermoelectric generator concept—which uses plutonium-238 as a fuel—has been in operation in space since its 1961 launch aboard a navigational satellite.

SNAP–19 Nimbus Generator

On April 14, 1969, two SNAP–19 isotope generators were successfully placed in orbit aboard NASA's Nimbus-III weather satellite. The two generators are currently in operation, supplying power for operation of the spacecraft. Having the SNAP–19's on board has allowed the satellite to obtain increased data over that which would have been possible with only the prime solar cell power system. SNAP–19 was developed for the AEC by Martin-Marietta at its Middle River, Md., facility in the initial phases and the work was completed by Isotopes, Inc., which took over Martin-Marietta's nuclear division in 1968.

SNAP–29

Because of budgetary priorities, the development of the SNAP–29 short-lived (3 months) generator was discontinued in 1969. A 400-watt generator was fabricated and assembled in June and tested by Isotopes, Inc., using electrical heaters. Thermal and electric performance was verified, although the development status of welding techniques on one component of the generator did not permit full life testing.

With the termination of the project, supporting work in development and production of polonium fuel was also terminated during the year. Final efforts included the demonstration of production feasibility of fuel forms intended for burnup and intact reentry at the AEC's Mound Laboratory and Pacific Northwest Laboratory and completion of some preliminary testing up to 1,200° C. (2,192° F.).

Transit Generator

The final design of the generator for the Navy's advanced navigational satellite has been completed by TRW Systems (Redondo

Beach, Calif.). With a design goal of 5 years of operation, the single 30-watt generator, using lightweight thermocouples and a new intact-reentry heat source technology, will supply total system power for the spacecraft.

Pioneer and Viking Generators

Adaptations of the SNAP–19 technology, incorporating an improved heat sources and thermoelectrics, are currently being qualified for NASA "Pioneer" Jupiter probes and the "Viking" Mars landing craft. Launches for these programs are scheduled in 1972 and 1973 for Pioneer and in 1975 for Viking.

Multi-Hundred Watt Generator Module

The Missile and Space Div. (Valley Forge, Pa.) of General Electric has started work on the first phase of a program to develop a more efficient, lightweight, long-life, plutonium-fueled, radioisotope thermoelectric power module in the 100 to 200-watt power level for use on a number of future space missions. This will be a basic building block for space power systems in the 100 to 1,000-electrical-watt range.

LUNAR ISOTOPIC SYSTEMS

SNAP–27 Lunar Power Supply System

The SNAP–27, fueled with Savannah River Plant-produced plutonium-238 that was fabricated into a heat source at Mound Laboratory, was developed for the AEC by the General Electric Missile and Space Division (Valley Forge, Pa.). It is providing over 70 watts of electric power to the Apollo Lunar Surface Experiments Package (ALSEP), an automated scientific measurements laboratory deployed on the lunar surface by the Apollo 12 astronauts on November 19, 1969. The generator is the sole power supply for the ALSEP and is designed for operation uninterrupted by sunset or by the extremely cold temperatures of the lunar night. The use of nuclear power in this application enables the automated experiments to continue to supply data for a year instead of the few weeks of daylight operation of previous non-nuclear power systems. The SNAP–27 was originally scheduled to be carried aboard the Apollo 11 but was replaced by the lunar heaters (see next page) because of a modified experimental program for the first landing (see photos in Introductory Chapter).

Lunar Heaters

Prior to the November 19 operation of the SNAP–27 power supply, two 15-thermal-watt plutonium-238-fueled isotopic heaters had been left on the moon to heat the passive seismic experiment package after the first manned lunar landing (see Introductory Chapter photo). They were launched aboard Apollo 11 on July 16, 1969, and placed on the moon by the astronauts on July 20, 1969. Their heat output maintained the critical components of the system above −60° F. during the long lunar night (14 earth days) when the external temperature drops to −250° F. The seismic package worked satisfactorily for a short time after the first lunar night and was still partially in operation in December. Indications were that the electronics system was still operative but the seismic recorders were not.

ISOTOPES FUEL DEVELOPMENT

The heat derived from the decay of radioisotopes can be used directly for heating or for conversion to mechanical or electrical energy by appropriate conversion devices. The isotopes must be selected, and their chemical and physical form developed, to provide such desired characteristics as type of radiation, half-life, and stability in the operational environment. Exhaustive development and test efforts are conducted to establish the capability of the fuel form to meet the operational requirements involved in practical energy systems.

Pioneer Spacecraft Heaters

In late December, the AEC received a request from the National Aeronautics and Space Agency to design, develop and deliver flight qualified radioisotope heaters to be used in conjunction with the attitude control system of the Pioneer spacecraft. The heaters which will be used to heat thrusters and their fuel supply tank are to be used on both the Pioneer "F" and "G" Jupiter fly-by missions. It is expected that three one-thermal-watt heaters will be used in each of three thrusters and two one-watt heaters will be inserted in the fuel tank on each spacecraft to prevent freezing of the hydrazine.

Curium-244

More than a kilogram of Savannah River Plant-produced curium-244 is being used by Oak Ridge National Laboratory, Pacific Northwest Laboratory, and the McDonnell Douglas Corp.'s Donald W. Douglas Laboratory (DWDL) at Richland, Wash., for isotopic heat source development. This radioisotope is the only practical long-lived isotope for thermionic conversion techniques, and may be lighter and more economical than plutonium-238 for use in thermoelectric systems. Compatibility experiments were carried out with refractory metals at temperatures in the neighborhood of 1,500° C. (2,732° F.) for 10,000 hours. The Oak Ridge work culminated in the design and fabrication of a one thermal kilowatt heat source planned for life-test operation at thermionic temperatures. The DWDL effort consisted of compatibility testing of curium sesquioxide (Cm_2O_3) with refractory metals at temperatures near 2,000° C. (3,632° F.) for 1,000 hours. Definition of thermal properties such as thermal diffusivity was pursued at Pacific Northwest Laboratory.

Plutonium-238

As an extension of fuel development activities carried out by the Los Alamos Scientific Laboratory and Battelle Memorial Institute on solid solution and molybdenum cermet (metal-ceramic) fuel forms, respectively, development was initiated on a solid solution cermet fuel form at LASL. This fuel form is being developed as one which promises more shock resistance and operation at higher temperatures than existing microsphere fuel form. Introduction of thoria to form a solid solution with plutonium enhances the thermodynamic stability and increases the thermal conductivity of the ceramic oxides.

Thulium-170

Material property studies are in progress by Sanders Nuclear Corp. (Nashua, N.H.), and the Oak Ridge National Laboratory to establish the feasibility of using thulium-170 oxide (half-life, 125 days) for isotopic fuel (thermal energy) applications for short-lived space and terrestrial power systems. The initial work has established that the oxide system was satisfactory for operating at temperatures through 2,900° F. Continuing work is evaluating the effects of additives and extending the compatibility data to increase containment reliability.

TERRESTRIAL ISOTOPIC POWER

Recent studies related to the life and marine sciences have placed increasing emphasis on the need for long endurance power sources for a variety of uses, including those to assist human body functions.

MARINE APPLICATIONS

For several years, the AEC has been actively engaged in the orderly development of long-lived radioisotope power sources for such applications as remote marine and land-based operations. In many cases, the unique characteristics of radioisotope devices make them the only practical long-lived power source for equipment used for underwater surveillance, weather buoys, navigational aids, seismic stations, weapons systems, offshore oil wells, and manned undersea habitats. The practicality of such devices was initially established by the first generation SNAP–7 series of radioisotope generators, which were successfully tested under a variety of conditions from the ocean bottom to remote Antarctica, proving the capability for safe, unattended operation.

SNAP–21 and SNAP–23

Upon completion of the SNAP–7 program in 1966, the AEC initiated development of a second generation of terrestrial radioisotope power sources in the 10–100-watt power range, designated as SNAP–21 and SNAP–23. The efficiency of these systems is almost double (6.5 to 7.0 percent) that of the first-generation devices. Through careful application of quality assurance techniques, their reliability, extended life capability, and reproducibility are now being demonstrated.

SNAP–21. The objective of the SNAP–21 project is to develop a series of compact strontium 90 fueled, 10- and 20-watt units of common design and technology, for general purpose deep-sea and ocean-bottom application. The design and development effort for the 10-watt units has been successfully completed. Ocean testing of the first three fueled prototype 10-watt units began in June 1969 off San Clemente Island, Calif. Design of the 20-watt units has been initiated. The Minnesota Mining and Manufacturing (3M) Co., St. Paul, Minn., is the prime contractor for this program.

SNAP–23. Development of the SNAP–23 is for providing economical, strontium-90 fueled power sources of common design and technology in the 25-, 60-, and 100-watt range terrestrial applications. The first electrically heated 60-watt system has been under test operation since December 1968. Fabrication and assembly of the first strontium-fueled prototype 60-watt mockup unit was scheduled for completion in January 1970. This program is being jointly managed by the 3M Co. and Westinghouse Astronuclear Laboratory.

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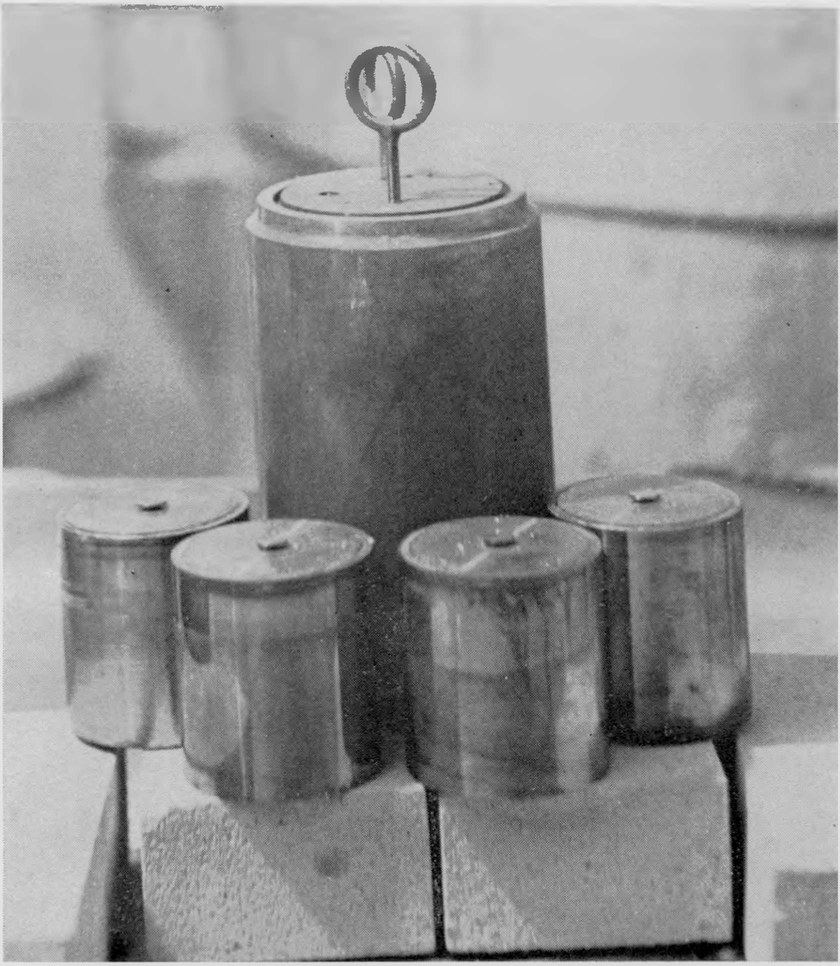
Large Isotope Kilowatt Systems

Based on limited design and engineering studies on radioisotope fuel selection, shielding studies, and energy conversion technology,



Five Strontium Titanate Fuel Sources were recently prepared and encapsulated by Oak Ridge National Laboratory's Isotopes Development Center for use in advanced versions of thermoelectric power generator devices. The four smaller 200-thermal watt sources will be used in the undersea SNAP-21 power conversion system. The taller 1,100-thermal watt source (the largest single radioactive strontium fuel capsule ever assembled) will be used to power a SNAP-23 device for remote terrestrial applications. The total amount of heat produced over the next 10 years by this large (28 pounds) source will be equal to that produced by burning about 15,000 pounds of fuel oil.

conducted at Oak Ridge National Laboratory, preliminary design efforts were initiated in 1969 for large isotopic systems in the kilowatt (thousands of watts—kw) range using both dynamic and thermoelectric conversion techniques. For each of the system designs a technical

One of Two Special Nuclear-Powered SNAP–21 thermoelectric generators, suspended in a support frame, is shown being maneuvered into place by Navy frogmen on the ocean floor about 150 feet under the surface off San Clemente Island, near Long Beach, Calif. The frame will keep the unit about 5 feet above the floor during an extended testing period. Ocean testing of three such 10-watt units, fabricated by the Minnesoto Mining and Manufacturing (3M) Co., St. Paul., Minn., began in June 1969.

development plan is being prepared which will present an estimate of the experimental and developmental resources necessary to develop these systems.

HEART ASSIST DEVICES

The AEC-sponsored studies on radioisotopically powered heart assist devices to aid or replace the blood pumping function of the natural heart have been continued to evaluate the radiation dose to a patient from such a device, to prepare radioisotopic heat sources that would result in the minimum radiation dose to a patient, and to evaluate the biological and physiological effects of implanted radiation sources on dogs as "artificial heart" devices. Three nuclear-powered, "cardiac pacemakers" (see photos) are already successfully operating in dogs.

Artificial Heart Studies

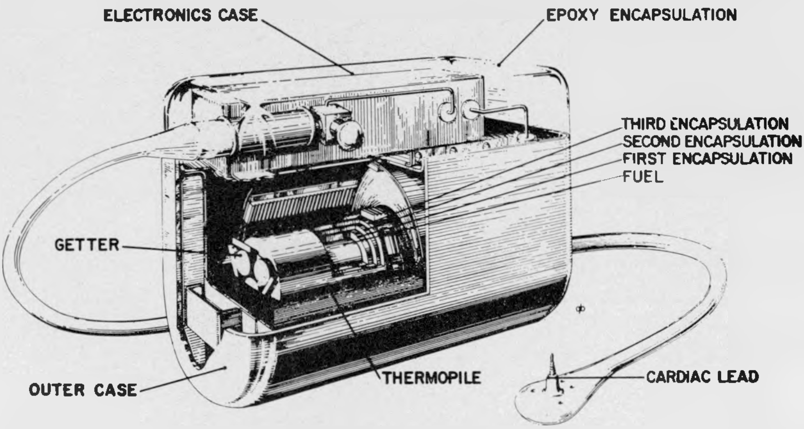
Isotopic Fuel Studies

Studies on shielding, dose prediction, and dose measurements were completed on promethium systems at the Pacific Northwest Laboratory. These were important because of the potential usefulness of promethium-147 in circulatory support systems and for establishing procedures for the dosimetry of other candidate radioisotopes, in particular, plutonium-238. The measurements were taken out to 20 cm. (7.8 inches) in tissue, whereas the current literature values all terminate at 4 to 5 cm. (1.5 to 1.9 in.). Some dose rates from plutonium-238 have also been measured by using a life-size "phantom" which simulates the human body.

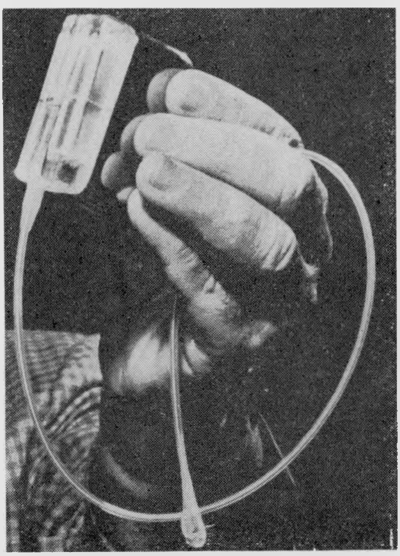
Plutonium-238 oxide is a more chemically stable fuel form than plutonium-238 metal. However, the neutron-emission rate from the natural oxide is about four times that of the metal. The increased emission rate results from the reaction of alpha particles (from the plutonium) with the oxygen-18 in natural oxygen to produce neutrons. Nine batches of plutonium-238 oxide were synthesized with an oxygen-18 content of less than 0.002 percent of the total oxygen. It was demonstrated that the neutron-emission rate from the oxygen-18-depleted oxide is reduced to approximately that of the electrorefined plutonium-238 metal.

Effect of Heat Sources Implanted in Dog

National Heart Institute (Bethesda, Md.) studies on two dogs with implanted plutonium-238 heat sources have been a significant contribution to the program to evaluate the physiological effects of additional heat from a power supply for an artificial heart. A 16-watt source was implanted in a dog for 26 months prior to its death, in October 1969, from unknown causes. A larger, 24-watt source has been implanted in a second dog since May 7, 1968, and the animal remains in apparent good health. The sources were fabricated by the AEC and loaned to the Institute for these studies.



Three Nuclear-Powered Cardiac Pacemakers, AEC-developed experimental models of plutonium-fueled cardiac pacemakers, were successfully implanted in dogs by the National Heart Institute at Bethesda, Md., during 1969. They have operated as planned and the development contractor, Nuclear Materials and Equipment Corp., Apollo, Pa., expects to provide several units of a prototype model to the National Heart Institute for further experimental testing in dogs in the near future; units are expected to be ready for clinical testing in human patients in 1971. A surgically-implantable nuclear powered cardiac pacemaker can provide important improvements in the capability for cardiac stimulation required in the treatment of "heart block," a relatively common cardiac affliction. Radioisotope devices have a useful lifetime of up to 10 years as compared to the 2 to 3 years presently experienced with battery-operated units. Drawing *above* is a schematic of the cigarette pack-sized unit (at *left*).



Chapter 10

ISOTOPIC RADIATION APPLICATIONS

ENVIRONMENTAL EFFECTS STUDIES

Technological achievements and increased standards of living have brought with them many environmental problems. The most notable of these are air and water pollution. To determine their impact on plants and animals, the presence of pollutants must be detected, their amounts measured, and their pathways followed to determine what damage they may cause. Radioisotope tracers and related analytical techniques are useful tools for these purposes.

Atmospheric Sulfur Pollution Analysis

Brookhaven National Laboratory [1] is using analysis of the variations of sulfur-32/sulfur-34 ratios in stack gas to study the source, quantities, and meteorological distribution of sulfur dioxide emitted to the atmosphere from fossil-fuel burning plants. During 1969, methods were developed for the rapid aerial sampling of gases near stacks and for the routine analysis of these samples by mass spectrometry. Field tests of the system have been made in New York City, in New Haven, Conn., and at the Keystone Power Plant near Pittsburgh, Pa.

Stack-Gas Analysis

Industrial Nucleonics Corp. (Columbus, Ohio), has produced a working model of an instrument capable of measuring sulfur dioxide (SO_2) in stack gas [2] to about 10 percent accuracy in the 100- to 4,000-p.p.m. range. Preliminary tests, recently carried out at Bituminous Coal Research, Inc., in Pittsburgh, Pa., showed that additional work

[1] See p. 185, "Annual Report to Congress for 1968."
[2] See pp. 185–188, "Annual Report to Congress for 1968."

is needed to reduce the time it takes for the instrument to respond to changes in sulfur dioxide concentration. The method involves bubbling a side stream of the SO_2 containing gas through a suspension of mercurous chloride where the SO_2 reacts to form soluble mercury ions. A continuous measure of the X-ray absorption by this solution gives an indication of the sulfur dioxide concentration.

Radiation Treatment of Wastewater

A joint AEC-Federal Water Pollution Control Administration (FWPCA) study on the practicality of using nuclear radiation for wastewater treatment was completed during 1969. The study defined potential areas of application which required further investigation. A Gulf General Atomic (San Diego, Calif.) research project is now in progress to investigate most of these areas and to evaluate critically the practicality of using radiation to treat those problems most likely

A Two-Part Filter Pack is being used by Brookhaven National Laboratory for the collection of sulfur dioxide (SO_2) and sulfur tetraoxide (SO_4) particulates in sampling powerplant stack plumes aloft as a part of the AEC's research and development for atmospheric sulfur pollution analysis. The scoop, mounted outside the plane, directs the air being sampled into the filter duct. The plane is also equipped to collect sulfur hexafluoride (SF_6) tracer samples and to measure and record temperature, pressure, relative humidity, and SO_2 concentration. The sulfur oxides samples collected are processed for mass spectrometric measurement of stable isotope ratios as part of the isotope ratio traced method for identifying and following pollutant sulfur developed under Brookhaven's atmospheric diagnostics program.

to respond—particularly those dealing with sludge handling and dewatering. Results to date have not shown any real potential for radiation treatment of wastewater.

High-Head Turbine Studies

The AEC has a cooperative project with the U.S. Bureau of Reclamation, Department of the Interior, for developing equipment and techniques for making highly precise radioisotope flow measurements in high-head [3] turbines and pumps. Accomplishments have included: (*a*) Development of equipment for injecting and withdrawing samples from high pressure rapidly moving streams in conduits; (*b*) reduction in the number of conduit diameters necessary for uniform mixing

[3] *High-head*—Water drops of more than 200 feet. See also pp. 221–222, "Annual Report to Congress for 1965."

A Radioisotope Technique in Stream Pollution Studies concerning the pulp and paper industry that does not introduce a radioactive element to the water has been developed at Washington State University (Pullman). The technique involves firmly attaching a stable iridium salt to the wood fibers. In the photo *above* an engineer collects ground wood pulp to which the nonradioactive iridium is added. These fibers are reintroduced into the pulp. Following the processing of the ground pulp, the waste water streams discharged from the plant are sampled and the water analyzed for the iridium-tagged wood fibers by neutron activation. By this method, sources of river pollution from paper plants can be discovered and, simultaneously, operational efficiency improved. The method has been used in a number of paper plants in the Pacific Northwest.

between injection points and sample withdrawal; (*c*) improvement in counting procedures with increased accuracy of measurement; and (*d*) a laboratory investigation of the use of tritiated water (in addition to bromine-82) as a tracer for making discharge measurements. A demonstration was held at Pole Hill Power Plant in Colorado, to show how the technique has been successfully adopted for measuring the efficiency of high-head water turbines, and to aid in the management of water resources. The method is faster, simpler, cheaper, and more precise than conventional techniques.

Insecticide Residue in Food Chain

An eggshell strength gauge developed in 1968 [4] by Oak Ridge National Laboratory has now been used by the U.S. Wildlife Service of the Department of the Interior to study the relationship between the strength of bird eggshells and the amount of insecticide residue in the birds' environmental food chain. The shells become more fragile as the amount of insecticide increases.

RADIATION PROCESSING

Process radiation is concerned with the preparation and processing of new and improved products of national economic value and utility employing radiation as an energy source to effect chemical, physical, and biological change. The primary objective is the development of technology necessary to advance large-scale uses of radiation.

The sterilization of medical supplies and the catalysis of ethyl bromide production are well established illustrations of industrial uses of ionizing radiation.

Wood Polymers

The use of radiation to produce wood-polymer composites is beginning to become significant. Wood is impregnated with an organic monomer and then irradiated to provide a product which has the desirable properties of both wood and plastic. During the year, American Novawood Corp. (Lynchburg, Va.), contracted to supply more than 10 acres of wood-polymer parquet flooring and paneling for the Kansas City International Airport. In August, the AEC Chairman participated in the dedication of a large radiation facility (Radiation Machinery Corp, Inc., in Parsippany, N.J., designed for production

[4] See p. 187, "Annual Report to Congress for 1968."

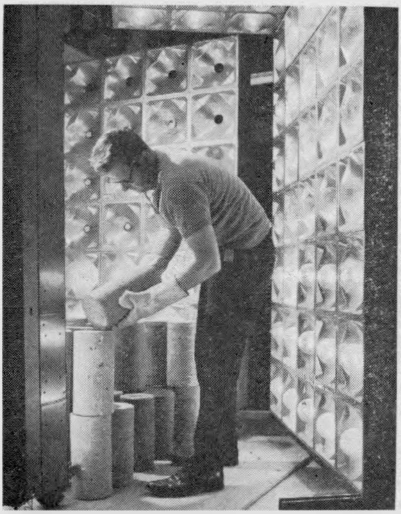
of wood-polymer products. The current annual capacity of all three commercial suppliers of radiation treated wood-plastic products exceeds 25 million square feet. At present, cobalt-60 is used exclusively as the radiation source. This commercial technology is a direct outgrowth of AEC-sponsored research and development work at Brookhaven National Laboratory and West Virginia University (Morgantown) in the late 1950's and early 1960's.[5]

Concrete-Polymers

Closely related to the wood-polymers are the concrete-polymers, prepared by a similar technique developed at Brookhaven National Laboratory. A report[6] covering the initial developments in the con-

[5] See pp. 275–276, "Annual Report to Congress for 1962"; pp. 189–190, "Annual Report to Congress for 1964"; pp. 212–213, "Annual Report to Congress for 1965"; and p. 231, "Annual Report to Congress for 1966."

[6] "Concrete Polymer Materials," First Topical Report, BNL–50134 (T–509) December 1968, available from Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. 22151, price $3.00.



New Concrete-Polymers developed at Brookhaven National Laboratory offer promise of greatly improved concrete for a variety of uses. In photo on *left* concrete specimens are shown being placed in an infrared oven for drying. After being impregnated with a liquid chemical monomer and then exposed to intense gamma radiation to polymerize (harden) the monomer, the concrete shows remarkable improvement in properties such as: Compressive strength, tensile strength, durability, freeze-thaw resistance, decrease in water absorption, and resistance to corrosion by sulfate brine. The photo provides dramatic evidence of the new concrete-polymer's ability to withstand freeze-thaw damage as compared to normal concrete (see other photo in Introductory Chapter).

crete-polymer program was issued in January 1969. Impregnation of ordinary concrete with a chemical monomer, followed by gamma irradiation to polymerize (harden) the monomer, results in a concrete product with vastly improved physical and chemical properties, particularly with regard to freeze-thaw characteristics and compression-tensile strength. The potential applications of this new material—generally as a new construction material—has led the following government agencies to participate with the AEC in cooperative programs in this area: Office of Saline Water, U.S. Bureau of Reclamation of the Department of the Interior; U.S. Army (Corps of Engineers); U.S. Navy (Civil Engineering Research Laboratory); U.S. Department of Agriculture; U.S. Bureau of Public Roads; and U.S. Bureau of Mines. In addition, cooperative programs with industry are being pursued through trade associations. The first such program, with the American Concrete Pipe Association, seeks to develop improved drainage and sewer pipes.

Food Preservation

The AEC's developmental work for the radiation preservation of foods was redirected following the Food and Drug Administration (FDA) 1968 decision not to approve the U.S. Army's petition for radiation-sterilized canned smoked ham for public consumption. Part of this reorientation was the decision by the AEC that the wholesomeness section of any future petition to FDA would be supported by results of AEC long-term animal feeding studies. In addition, the technical effects section would be supported by large-scale, simulated and actual, commercial shipping and storage studies. Such studies are in progress on strawberries and papayas and are required to demonstrate to the FDA that the irradiation treatment does impart the desirable technical effect the petition is attempting to show even after the stresses of commercial shipping and storage have been encountered. The results, thus far, have been acceptable.

The shipping studies will be completed during 1970, and, in the case of strawberries, completion will coincide with the completion of the 2-year feeding studies. The petition to FDA for radiation control of decay in strawberries will be submitted shortly thereafter. The preparation of the entire petition for the use of radiation to disinfect, delay ripening, or control decay for papayas, will await the scheduled (1971) completion date of the 2-year feeding studies. Petitions for the irradiation of haddock and cod fillets will await the completion of microbiological studies before starting the required 2-year feeding studies.

Simulated and commercial shipping studies, as well as dosimetry studies, are continuing.

Portable Irradiators

A portable cesium irradiator [7] has successfully completed its tour of the food processing areas demonstrating to industry, in their own plants, the benefits of irradiation when applied to their products. About 75 companies in 12 States participated in this program with over 75,000 pounds of products being irradiated in the truck-mounted facility.

In support of domestic and foreign food irradiation research, Brookhaven National Laboratory has designed, modified, and installed several types of portable irradiators. Shipboard irradiators, fueled with about 30 kilocuries of cobalt-60, are currently operating (as land-based facilities) in Israel, Iceland, and Nebraska. Three Brookhaven portable cesium developmental irradiator (BPCDI) units, each powered with 110 kilocuries of cesium-137, have been fabricated for installation in foreign countries. A cobalt-fueled, pool-type unit is ready for installation in Pakistan as soon as governmental arrangements are complete.

IOTOPIC RADIATION SYSTSEMS

While large radiation sources are being used as agents in the processing of new and unusual materials, smaller sources, or small amounts of radioisotopes, are employed to measure and trace materials in a variety of processes. Some of the latter are routine techniques adapted to fit novel situations. Many of these applications have already proven to have value in the systematic solution of industrial, medical, or scientific problems; many being developed to meet problems of national concern.

Radioisotope X-ray Fluorescence

The portable radioisotope X-ray fluorescence analyzer[8] made a successful transition to industry during the year. Three U.S. companies are now manufacturing commercial models of the instrument—Panametrics, Inc. (Waltham, Mass.); Texas Nuclear Corp. (Austin, Tex.); and The Harshaw Chemical Co. (Cleveland, Ohio).

The portable isotopic X-ray fluorescence analyzer has been adapted by Panametrics, Inc., for use in criminal analysis as a hidden mark

[7] See p. 190, "Annual Report to Congress for 1967."
[8] See p. 189, "Annual Report to Congress for 1968."

detector, and a bullet-hole detector. In both instruments the low energy gamma rays from cadmium-109 are used to excite X-rays from a minute amount of lead. The hidden spot detector can authenticate a document or object by identifying a previously placed lead salt (or other chemical) spot. The bullet-hole detector senses the minute trace of metallic lead around the hole. Previously, it was very difficult to obtain evidence in the field to prove that a hole was caused by a bullet.

Mössbauer Effect

In the 10 years since its discovery, the recoilless resonant absorption of gamma rays—now generally called the "Mössbauer Effect"—has been used for specific research studies in physics, chemistry, and metallurgy. The technique has been found to be especially useful in studying the metallurgical properties, composition, and structure of iron and steel products. However, in past years, application of the Mössbauer technique was limited to very thin samples (about 0.001 inch thick) in order to detect the radiation transmitted through the sample by the low-energy radioisotope source required in the technique. Also, the time required to make a measurement was prohibitively long in many cases.

Recent results, obtained under AEC contract by the International Chemical and Nuclear Corp. (Irvine, Calif.), and by the National Bureau of Standards, show that it is now possible to make Mössbauer measurements using backscattered rather than transmitted radiation. The backscatter technique permits nondestructive measurements to be made on thick sample materials and finished products such as steel plate, and even on samples that are not flat such as steel ball bearings. The time required for a measurement has been greatly reduced through the development of improved Mössbauer detectors. Some additional effort is required in order to develop Mössbauer backscatter equipment engineered for field and in-plant uses, and to evaluate the technique for specific applications.

Medical Isotopes

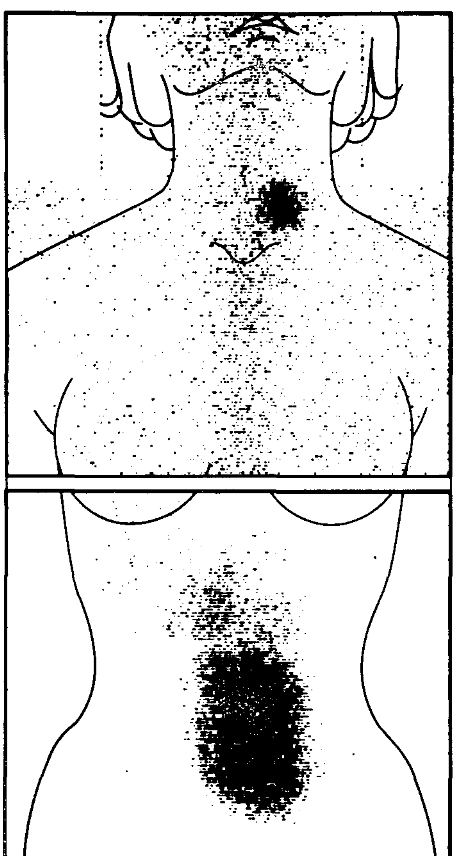
In cooperative studies with medical groups which have the responsibility for their biological assessment, Brookhaven and Oak Ridge National Laboratories are developing radioisotope products for diagnostic evalution.

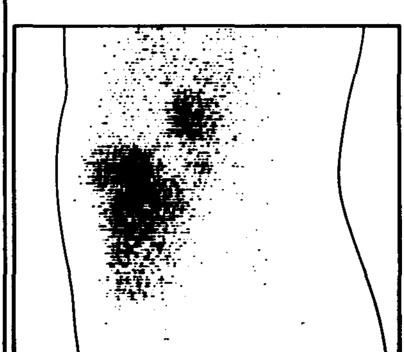
During the year, production procedures for gallium-67 were established by Oak Ridge National Laboratory and studies by the Oak

Ridge Associated Universities have shown this isotope to be extremely promising in diagnosing Hodgkins disease and certain types of tumors. At Brookhaven, a radioisotope generator and infusion system to provide short half-life silver-109m (40 seconds)[9] was developed for dynamic studies of animal and human systems. Work related to the molybdenum-99/technetium-99m generator system at both Oak Ridge and Brookhaven has resulted in a better method for separating high quality molybdenum-99 parent and in a procedure for synthesizing technetium-99m labeled DTPA,[10] which appears to be a most desirable

[9] The superscript "m" stands for metastable; indicating that the isotope is unstable and decays without particle emission to a more stable form of the element.
[10] *Diethylenetriaminepentaacetic acid*—An antiradiation drug.

A New Gallium-67 Production Process, developed at Oak Ridge National Laboratory, is providing medical science with a radioisotope that promises to be extremely useful in diagnosing Hodgkins disease and certain types of tumors. The scans show the location of malignant (cancerous) tissue and were made with the aid of 2.93 millicuries of gallium-67 (Ga^{67}) which was introduced intravenously. The body scans, made 3 days later, are of a patient in the hospital operated by the medical division of Oak Ridge Associated Universities. Front view of the upper torso, lower torso, and a side view of the abdomen, show a large abdominal tumor and a smaller tumor at the base of the neck. This experimental method of locating cancerous tissue may prove useful both in diagnosis and in planning treatment of the disease.





agent for brain scanning. Interestingly enough, more than 2,000 diagnostic procedures are now being carried out daily in the United States alone, using technetium-99m.[11] A high percentage of these are brain scans. Other cooperative studies are in progress using iron-52 magnesium-28, chlorine-36, potassium-43, and indium-111 for diagnostic research. Oak Ridge and Brookhaven National Laboratories have both built strontium-90 and cobalt-60 blood irradiators that are being used for treating diseases such as leukemia; commercial suppliers have begun to satisfy demands in this area.

[11] See pp. 222–224, "Fundamental Nuclear Energy Research—1967."

Chapter 11

PEACEFUL NUCLEAR EXPLOSIVES

THE PLOWSHARE PROGRAM

The AEC's Plowshare program has the responsibility for the development of a peaceful nuclear explosion technology which offers great potential for improving natural resources utilization and for large-scale civil works projects.

During 1969, the second joint Government-industry experiment, Project Rulison, was successfully conducted to further the technology of stimulating the recovery of natural gas from gas-bearing formations of low permeability. Also, as a result of past nuclear excavation experiments, a significant body of information has been accumulated on the capability of using nuclear explosions to simultaneously break and move tremendous quantities of earth. Research was also continued to develop means of using underground nuclear explosions for a number of scientific studies.

Plowshare Services

The AEC's authority for providing nuclear explosion services to users of the Plowshare technologies is limited, under existing law, to research and development, including demonstration purposes only. Government and industry officials most familiar with Plowshare technologies testified, during 1969, before the Joint Committee on Atomic Energy of Congress regarding this limitation and on pending legislation [1] that would authorize the AEC to cooperate with industry for other than just research and development purposes. Throughout the testimony careful consideration was given to establishing the scope and conditions under which the AEC is to provide a commercial nuclear explosion service in the United States and abroad.

[1] See p. 195, "Annual Report to Congress for 1968."

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UNDERGROUND ENGINEERING

Some of the most promising applications for contained nuclear explosions are those involving the development of natural resources. These applications include natural gas stimulation, fracturing oil shale for subsequent *in-situ* retorting, preparation of ore bodies for *in-situ* leaching, and the formation of underground reservoirs for storage of natural gas or disposal of wastes.

Natural Gas Stimulation

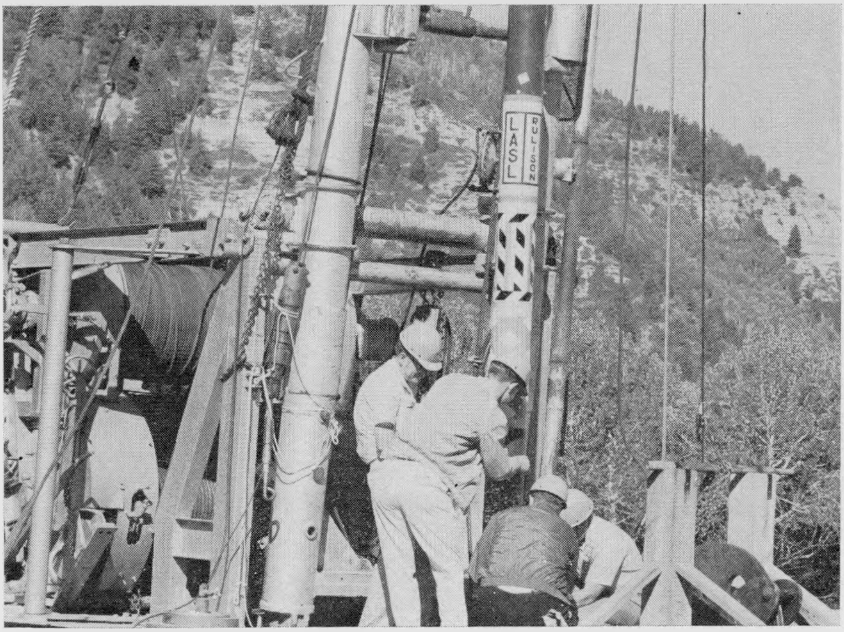
Experts have forecast that by the mid-1970's U.S. recoverable natural gas reserves will not be able to meet demands unless new, and more economic, recovery techniques are developed. Accordingly, a high degree of interest is being shown by Government and industry to develop new ways to stimulate recovery of this vital resource. There is a growing recognition of the value of the new nuclear underground engineering technology since nuclear explosives appear to offer an effective and economic means of increasing the productivity of natural gas reservoirs that are not amenable to conventional techniques. To date, two joint Government-industry experiments have been conducted and several others are planned.

Project Rulison

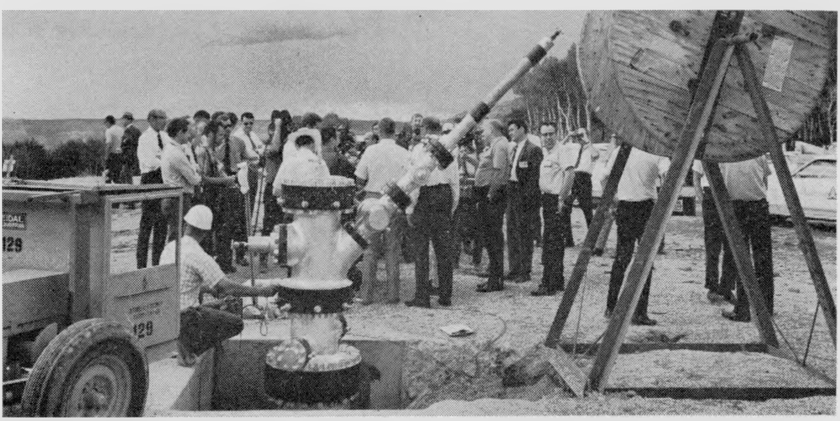
On September 10, 1969, a 40-kiloton nuclear explosive was detonated 8,430 feet beneath the surface in Garfield County, 45 miles northeast of Grand Junction, Colo. The explosion was part of Project Rulison, a joint experiment of the AEC, the U.S. Department of the Interior, and the Austral Oil Co., with CER Geonuclear Corp.[2] acting as program manager. The Los Alamos Scientific Laboratory provided technical direction of the project for the AEC.

Among the observers attending the detonation were several small groups of individuals (mostly from Denver and Boulder, Colo., over 100 miles away) who protested the experiment. Lawsuits to enjoin the conduct of Project Rulison were instituted by a local official, a conservationist group, and several private parties. The Colorado Federal District Court, following hearings, denied the injunction requests and this action was affirmed by the U.S. Court of Appeals for the Tenth Circuit at Denver. Plaintiffs' requests for an injunction against the reentry and well testing phase of the project will be heard by the District Court in early 1970.

[2] See footnote 5, p. 200, "Annual Report to Congress for 1967."



The Second Plowshare Natural Gas Stimulation experiment, Project Rulison, was detonated in western Colorado, on September 10, 1969. Photo *above* shows the 40-kiloton nuclear explosive being lowered into the 8,430-foot hole a few days before the detonation. Photo *below*, taken at ground zero shortly after the detonation, shows the post-shot briefing that was held for some of the observers. The technician (in white hardhat) is monitoring the sealed-off wellhead for radiation leakage—there was none. Rulison was sponsored by the Austral Oil Co., Inc. (Houston, Tex.), the AEC, and the U.S. Dept. of Interior, with CER Geonuclear Corp. (Las Vegas, Nev.) as program manager and Los Alamos Scientific Laboratory (LASL) providing the specially-built nuclear explosive and technical direction. Drill back—to determine the results of the detonation—is expected to start in the spring of 1970.



Objectives. The specific objectives of the Rulison experiment are: (*a*) To determine changes in gas production and recovery rates; (*b*) to gather additional engineering knowledge of the use of nuclear explosions for gas stimulation; (*c*) to determine further gas quality with regard to radioactivity and to evaluate various techniques for further reduction in radioactive contamination to the gas; and (*d*) to add information to the results of the 1967 Project Gasbuggy experiment that could further provide a basis for predicting results of future projects.

Data Collection. Preliminary evaluations of the data from the Rulison detonation indicated that the explosive performed as expected, with a yield of about 40 kilotons (the equivalent of 40,000 tons of TNT). There was no release of radioactivity to the atmosphere from the explosion. A wellhead pressure of approximately 400 pounds per square inch gauge (p.s.i.g.) was initially measured on September 16, and on December 21, the shut-in pressure had risen to 2,510 p.s.i.g. It is estimated that the gas pressure will not significantly increase beyond this amount by the time the post-detonation reentry program starts sometime in the spring of 1970. Many months of reservoir production test and evaluation will be required to determine the success of the experiment.

Project Gasbuggy

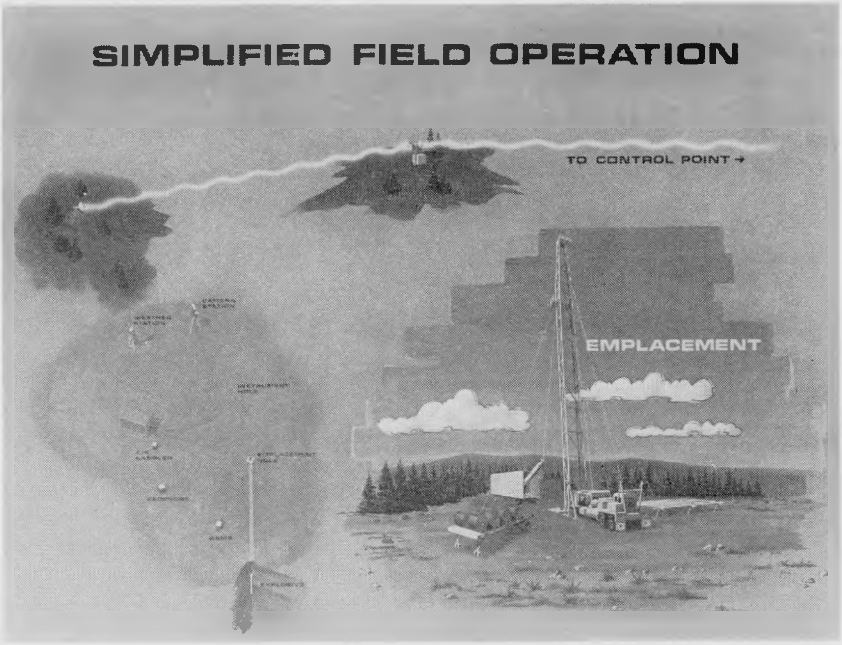
During the year, production tests on the Project Gasbuggy explosive emplacement well were conducted by the project participants—El Paso Natural Gas Co., the AEC, and the U.S. Bureau of Mines of the Department of the Interior. The tests measured the rate of influx of gas into the explosion-created chimney from the surrounding rock formations as gas was withdrawn at rates necessary to maintain preselected bottom-hole pressures. It is estimated that over a period of 20 years, the cumulative production of gas will be about 1 billion cubic feet; this represents about 20 percent of the gas in place under 160 acres at the Gasbuggy site. By comparison, the predicted cumulative production, over a 20-year period from a nearby older conventionally drilled well, is 125 million cubic feet of gas. The Gasbuggy estimate represents an eightfold increase in production and compares with a three to sevenfold increase predicted prior to the detonation.

Project Gasbuggy, in the San Juan Basin of New Mexico, was the first (Dec. 10, 1967) nuclear detonation in which private industry was a participant and the first industry-Government experiment for stimulating natural gas production by means of a nuclear explosion.[3]

[3] See pp. 199–200, "Annual Report to Congress for 1967."

Other Gas Stimulation Proposals

Several other gas stimulation experiments have been proposed or brought to the attention of the AEC. The purpose of these experiments



Progress In The Simplification of Operations has been made in developing two concepts for simplified field operations systems in conducting Plowshare experiments. The purpose is to reduce the number of personnel, cost, and time required to field the experiments, and ultimately, commercial Plowshare applications, once AEC's participation in them is authorized by law. Under one concept, the system provides for microwave transmission of commands from the control point to the arming and firing station on or near the point on the surface immediately above the buried explosive (surface ground zero) and nearby instrumentation, as well as providing microwave transmission of experimental data and safety related information from ground zero instruments back to the control point. This system can be used for cratering or contained detonations and was partially tested when the Schooner explosive was detonated (Dec. 1968) by radio-link command. The other conceptual simplified field operations system was tested with Project Rulison on September 10, 1969. A significant feature of the latter system is the use of a single cable for emplacing and firing the explosive which is delivered to the site preassembled. This system more closely approximates a commercial application where a minimum amount of experimental data is involved. It is anticipated that the reduced costs resulting from the use of this system will encourage greater industrial interest in applications of nuclear explosives for underground engineering.

would be to further extend the Gasbuggy and Rulison data for economical recovery of natural gas as a result of nuclear stimulation.

Dragon Trail. Continental Oil Co., and the CER Geonuclear Corp., are considering a project to extend the knowledge of gas stimulation to a gas-bearing formation with different geological characteristics than either the Rulison or the Gasbuggy reservoirs. The proposed site is about 50 miles north of Grand Junction, Colo. The industrial proponents are currently carrying out internal evaluation of the proposed experiment and possible modifications to the technical objectives prior to developing plans to proceed with the project.

Wagon Wheel. The El Paso Natural Gas Co. (EPNG) is studying the feasibility of using nuclear techniques to stimulate gas-bearing deposits in the Pinedale area of the Green River Basin of western Wyoming. A feasibility study agreement was executed by the company with the AEC and the Department of the Interior on December 24, 1968. EPNG is currently in the process of drilling a potential site evaluation hole that will provide necessary geologic and natural gas reservoir characteristics.

WASP. An additional Pinedale, Wyo., area gas stimulation project named WASP (Wyoming Atomic Stimulation Project) has been proposed by a joint venture group headed by the International Nuclear Corp. of Denver, Colo. A project definition agreement was executed by WASP and the Government on July 30, 1969. A preliminary site evaluation has been conducted and work is progressing toward a detailed design for the project.

Other Underground Engineering Proposals

Work continued in 1969 to design experiments for investigating the use of nuclear explosives to develop other natural resources. Experiments proposed or brought to the AEC's attention by industrial companies are currently in various stages of planning:

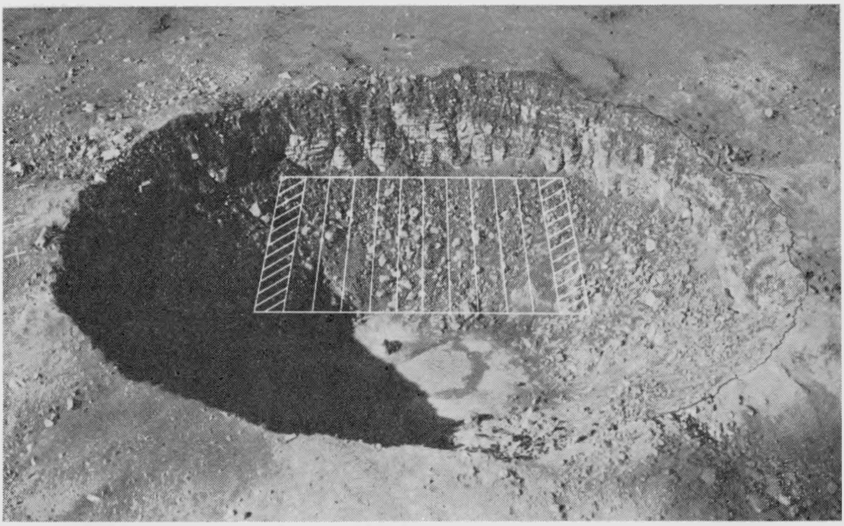
Name	Industrial partner(s)	Possible location of the experiment
Bronco:[1] (In-place retorting of oil shale)	Consortium of major oil companies and CER Geonuclear Corp.	Colorado.
Utah: (In-place retorting of oil shale)	Western Oil Shale Corp. and CER Geonuclear Corp.	Utah.
Sloop:[2] (In-place leaching of copper)	Kennecott Copper Corp	Arizona.
Ketch:[3] (Underground gas storage)	Columbia Gas System Service Corp	Appalachian region of U.S.

[1] See pp. 242–244, "Annual Report to Congress for 1966."
[2] See p. 204, "Annual Report to Congress for 1967."
[3] See pp. 244–246, "Annual Report to Congress for 1966."

NUCLEAR EXCAVATION

The potential of underground nuclear explosions for large excavation projects covers a wide range of possible uses such as: Navigable waterways, dams or storage reservoirs, harbors, and transits for highways and railroads through mountainous terrain.

During 1969, the AEC continued to analyze data from past cratering experiments conducted at the Nevada Test Site. These experiments produced important technical data relative to the capability of a nuclear explosion to simultaneously break and move tremendous quantities of earth. Much of this information was accumulated in support of the Atlantic-Pacific Interoceanic Canal Study Commission which is responsible for studying the feasibility of constructing, by nuclear or conventional means, a sea-level canal between the Atlantic and Pacific Oceans.



The Results of Project Schooner, the third in a series of nuclear excavation experiments in support of the Atlantic-Pacific Interoceanic Canal Study Commission's program were under analysis during 1969 providing useful information for the nuclear excavation program. The 35-kiloton explosion excavated a crater in hard rock about 852 feet in diameter and 208 feet deep at the AEC's Nevada Test Site on December 8, 1968. The explosive was emplaced at a depth of 355 feet below the surface of the ground. Schooner provided information on cratering effects from an explosion, at a yield rate many times greater than previous experiments in hard rock and demonstrated the effects of a greater moisture content in the rock on crater characteristics. For a comparison of size, a football field has been drawn in the crater.

The AEC's participation in the study has included: (*a*) On-site bioenvironmental surveys and safety studies; and (*b*) assistance in the development of engineering design and costs for such a nuclear-excavated canal.

Cape Keraudren

Early in 1969 the United States formally agreed to a proposal made by the Government of Australia to participate in a joint feasibility study for using nuclear explosions to develop a harbor at Cape Keraudren on the northwest coast of Australia. However, the interested mining company reevaluated its opportunities of mining and marketing iron ore, which was to be the principal product shipped through the proposed harbor. The evaluation caused the Australian and U.S. Atomic Energy Commissions to conclude that there was insufficient economic basis for proceeding with the feasibility study of that harbor. The two Atomic Energy Commissions continue to be interested in the possible use of nuclear explosions for harbor construction and are continuing to review the practicability of applying this technology to other possible harbor sites.

Arizona Water Study

Work continued on a feasibility study of the possible applications of nuclear explosions to water management in the State of Arizona. Given the name "Aquarius," the study is being carried out jointly by the AEC, the Department of the Interior, and the State of Arizona. It is expected that the study will be completed and published in 1970.

SCIENTIFIC STUDIES

Research continues to develop means of using underground nuclear explosions as a source of neutrons for scientific experiments. On July 16 a Plowshare experiment was conducted at the Nevada Test Site in conjunction with the underground nuclear event Hutch (see appendix 4), to produce heavy elements. Samples of the debris have been recovered by drilling into the underground region. Analyses of these samples by Lawrence Radiation Laboratory, Livermore, indicate the integrated neutron flux was approximately two to two and a half times that of the best previous experiments.[4]

[4] See pp. 257–258, "Annual Report to Congress for 1966."

Special Laboratory Studies

Research work at Oak Ridge National Laboratory continued in 1969 with the main attention given to laboratory studies on the distribution and fate of radionuclides created in underground engineering applications. This work is to: (*a*) Evaluate the chemical and metallurgical processes for reduction of radioactive contamination in products; and (b) assess the probable exposures from the use of such products. The Savannah River Laboratory continued its study of the effects on chemical systems of exposure to intense gamma radiation resulting from nuclear explosions and is also developing analytical techniques for measuring composition of post-shot debris.

The U.S. Department of the Interior's Bureau of Mines Petroleum Research Center at Laramie, Wyo., which studies the problems of extracting oil from oil shale by retorting, announced in 1969 that oil has successfully been separated from shale in an underground retort. The technique involves fracturing shale underground, then heating it in place to convert its organic matter into oil, which is then recovered through wells. The AEC has cooperated with the Bureau in this research to explore the possibility of using nuclear detonations to fracture the shale deposits underground.

PROGRAM DEVELOPMENTS

During 1969 the AEC continued to provide industry, and the public, with information about the potential benefits of nuclear explosives. In view of the rapid expansion in the volume of Plowshare scientific and technical literature and to improve dissemination of this information to the public, the AEC, in conjunction with other Gasbuggy and Rulison participants, has assembled "open file" information at the following locations: Federal Center, Denver, Colo.; Petroleum Research Center, Bartlesville, Okla.; and Nevada Southern University, Las Vegas, Nev. This information consists of "raw data" and is assembled primarily for industry.

Chapter 12

INTERNATIONAL AFFAIRS AND COOPERATION

INTERNATIONAL COOPERATION

The United States maintained its leadership in developing peaceful uses of nuclear energy. Cooperation with other nations and international organizations in the exchange of information, supply of materials, and training of personnel continued throughout the year. For the ninth consecutive year, AEC Chairman Seaborg headed the U.S. Delegation to the General Conference of the International Atomic Energy Agency (IAEA); he also visited Romania, Czechoslovakia, the U.S.S.R., Hungary, Portugal, Sweden, and Switzerland in furtherance of the United States' policy to advance the peaceful uses of atomic energy. Other Commissioners also made trips abroad to confer with atomic energy officials.

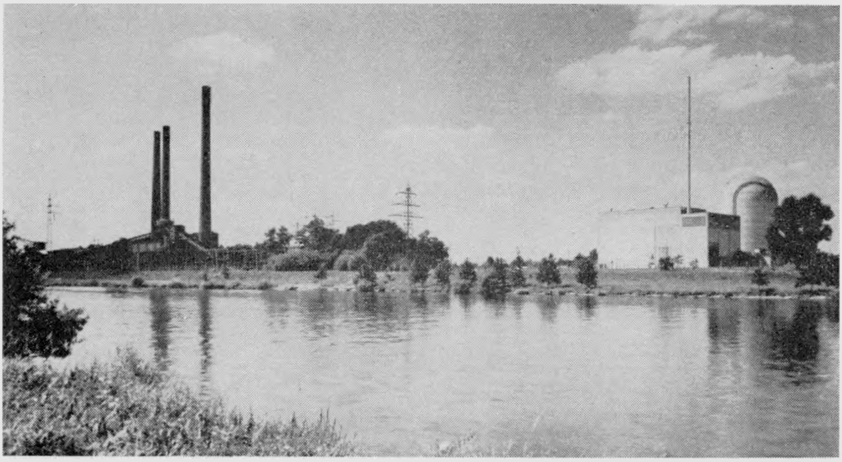
Beginning in January 1969, toll enrichment—the contractual arrangement by which the uranium-235 content of natural uranium is increased—became the preferred method of supplying enriched uranium for reactors abroad. The 17 foreign toll enrichment contracts signed since the beginning of the year have an estimated revenue, over the term of the contracts (up to 30 years), of approximately $400 million (see Table 3, Chapter 1—Source, Special, and Byproduct Nuclear Materials).

COOPERATIVE ARRANGEMENTS

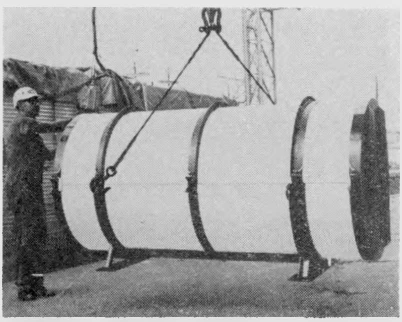
At the end of 1969, 32 Agreements for Cooperation in the Civil Uses of Atomic Energy between the United States and other nations and organizations were in effect (see appendix 6 for listing). The majority of these agreements cover cooperation in the development of the peaceful uses of atomic energy, and involve research and power reactors and the transfer of special nuclear materials for specific reactor projects, as well as the exchange of information and safeguards on U.S.-supplied material. During the year, the United States negotiated long-term research and power agreements with Argentina and Austria. These agreements will have a duration of 30 years. Their major purpose is to expand cooperative activities in atomic energy by providing for the supply of enriched uranium fuel necessary for the long-term requirements of power reactors planned for the respective national atomic energy programs.

During the year, a 10-year superseding research agreement was concluded with Portugal, and the agreement with Iran was amended to extend it for 10 years. The agreement with Greece was also amended to allow the transfer of highly enriched fuel for use in Greece's research reactor. Under the terms of the "private ownership" legislation [1] en-

[1] See pp. 12–15, "Annual Report to Congress for 1964."



Toll-Enrichment Services in AEC facilities became available to foreign as well as U.S. nuclear power reactor owners on January 1 and by the end of the year, 17 foreign contracts for increasing the uranium-235 (fissionable) content of natural uranium had been signed. Shown at *left* is the first foreign product shipment, made on January 6, from the Oak Ridge Gaseous Diffusion Plant. The material was destined for use in the 15-Mwe., U.S.-built (General Electric) boiling water reactor at Kahl am Main in West Germany. The plant (shown at *right* in photo *above*) has been in operation since 1960.



acted in 1964, the agreements include provisions permitting private persons to make arrangements for the international transfer of special nuclear materials under AEC license and in accordance with agreements for cooperation.

International Atomic Energy Agency

The United States continued its strong support of the International Atomic Energy Agency (IAEA) through cooperation in all of the Agency's activities, and through contributions to both its assessed and voluntary budgets which support technical assistance for developing nations. An IAEA symposium and two training courses were held in the United States in 1969.

The 102-member IAEA held its 13th General Conference in September. The Agency's program and budget for 1970 was approved, as well as a report by its Board of Governors concerning IAEA's role in connection with nuclear explosions for peaceful purposes. In this regard, Article V of the proposed Treaty for Non-Proliferation of Nuclear Weapons (see summary item in Introductory Chapter) provides that nonnuclear weapon states partly to the treaty will be able to obtain the benefits of nuclear explosions for peaceful purposes "under appropriate international observation and through appropriate international procedures." The approved report concludes that performance of these functions is within the Agency's technical competence and clearly fall within the scope of its statutory functions.

The United States continued its assistance to the IAEA safeguards program by providing the services of technical experts, sharing the results of research and development, and by providing safeguards training opportunities for Agency staff members.

It is U.S. policy to transfer to the IAEA the safeguards responsibilities provided for in various bilateral agreements for cooperation in the civil uses of atomic energy between the United States and other countries through negotiation of trilateral agreements among the United States, the IAEA, and the country involved. A total of 20 trilateral agreements are in effect, and several others are being negotiated. (See also Chapter 2—"Nuclear Materials Safeguards," on other aspects of safeguards activities.)

European Atomic Energy Community (Euratom)

The 10-year U.S.-Euratom research and development program on light water technology expired in June 1969. The program consisted of about 138 separate tasks conducted under contract in the facilities of private corporations both in Europe and the United States. It was funded in approximately equal parts by both sides at a total expenditure of about $55 million. This program materially assisted the growth of reactor technology in Europe as well as the AEC domestic program. U.S. cooperation with Euratom has continued primarily in the areas of furnishing enriched uranium reactor fuels in accordance with U.S.-Euratom supply contracts as well as the exchange of technical information.

European Nuclear Energy Agency (ENEA)

The AEC continued to cooperate with the European Nuclear Energy Agency (ENEA) programs through exchange of information on a broad range of subjects in the field of peaceful uses of atomic energy. The arrangement to collaborate in the area of high temperature gas-cooled reactors was extended to March 31, 1970. Also, during 1969, the arrangement between the U.S. and the ENEA to exchange information on nuclear data and nuclear energy computer programs was extended for 3 years.

Inter-American Nuclear Energy Commission (IANEC)

The Seventh Inter-American Nuclear Energy Commission Meeting was held in Washington, D.C., November 18–21, 1969, with 13 Western Hemisphere countries, including the United States, represented. The IANEC approved resolutions on: IANEC participation in the Organization of American States regional program of scientific and technological development; establishment of nuclear energy projects with short- and long-range economic significance; and support for relevant nuclear energy development programs being undertaken by other international organizations.

Technical Exchange Arrangements

In accordance with the U.S. policy of exchanging information on nuclear science and technology under technical exchange agreements with foreign countries, arrangements in selected areas of fast reactor information were concluded in 1969 with Japan, Switzerland, and Canada. Implementation throughout the year of approximately 40 foreign exchange arrangements continued. Countries interested in the potential uses of nuclear energy in agro-industrial complexes were kept informed of developments in this field.

Personnel Training Assignments

Advanced research opportunities in the field of peaceful uses of nuclear energy continue to be offered to foreign nationals at AEC facilities. The areas of cooperation have been broadened and strengthened through specific technical arrangements and opportunities to pursue individual research programs or training have been diversified. Short-term courses and individual research opportunities in various areas continue to be offered by the Oak Ridge Associated Universities, Inc., and the Puerto Rico Nuclear Center. A new series of workshops in safeguards techniques has been held at the Argonne National Laboratory and a special 2-week orientation course in regulatory functions was held in December at AEC Headquarters, with 11 countries represented. (See also Chapter 2.)

Since 1955, foreign nationals participating in research at AEC facilities have numbered more than 6,300. (See Chapter 14 for further discussion of training activities.)

Cooperation With the Soviet Union and Soviet Bloc Countries

Pursuant to the Memorandum on Cooperation between the AEC and the Romanian Committee on Nuclear Energy, Chairman Seaborg opened the AEC's "Atoms-in-Action" Center in Bucharest in October 1969. Additional exchange projects, including the loan of a gamma facility, were arranged with Romanian scientists.

Under the Memorandum on Cooperation with the U.S.S.R. State Committee on Nuclear Energy, which provides for the reciprocal exchange of scientific personnel and information in the field of the peaceful uses of atomic energy, a delegation of Soviet reactor specialists toured AEC laboratories and nuclear power installations for a 2-week period in November. A U.S. team will visit the U.S.S.R. early in 1970 for a reciprocal tour of Soviet nuclear power facilities.

Laboratory-to-Laboratory Arrangements

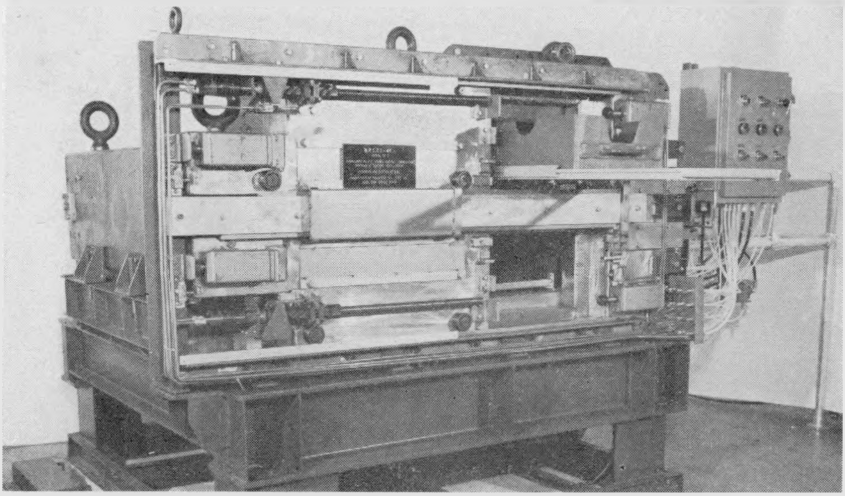
Scientific cooperation between AEC and foreign laboratories was continued in 1969: Oak Ridge National Laboratory and the Pakistan Institute of Science and Technology; Argonne National Laboratory and Tsing Hua University in Taiwan; Argonne National Laboratory and the Salazar Nuclear Energy Center in Mexico; Brookhaven National Laboratory and the Democritus Nuclear Center in Greece; and, to the extent that funds remaining from previous years were available, the Puerto Rico Nuclear Center and the Instituto de Asuntos Nucleares in Colombia.

Irradiator Loans

AEC has loaned portable irradiators to Argentina, Iceland, Israel, Peru, and the Organization of American States (Inter-American Institute for Agricultural Science at Turrialba, Costa Rica), for use in programs involving food irradiation, sterilization of medical supplies, and insect eradication through the sterilization of male insects. Information obtained from these programs is made available to the AEC. Commitments for irradiator loans have been made to Chile, Republic of China (Taiwan), Korea, India, and Pakistan. In addition, a 10,000-curie source was loaned to Venezuela for use in irradiation experiments.

NUCLEAR DESALTING

International interest continues in the potential of dual-purpose nuclear power-desalting plants as a large-scale source of fresh water and electricity. The IAEA served as a focal point for international cooperation in this field.



One of the Three Brookhaven portable cesium development irradiators (BPCDI) designed at Brookhaven National Laboratory for shipment overseas is shown *above.* This one, fabricated by Radiation Facilities Inc. (Lodi, N.J.), is being prepared for use in India, another will go to Chile, and a third is already in operation in Argentina. The BPCDI units are powered by 110 kilocuries of cesium-137 and are being loaned by the U.S. for use in foreign developmental programs on food irradiation, insect eradication, and sterilization of medical supplies.

Project Studies

A study on the potentials of nuclear power-desalting plants as a means to agricultural and industrial development, by providing quantities of fresh water and electricity to the Middle East, was continued by the AEC through its Oak Ridge National Laboratory, with the cooperation of the IAEA. Visits were made by an ORNL study team and IAEA representatives to Israel and to the United Arab Republic (UAR), Jordan, and Lebanon. Oak Ridge also provided technical assistance in connection with India's interest in the potential application of nuclear-powered "energy centers" to help solve chronic water and power shortages in various locations in India. The United States and Mexico continued consideration of a report by a U.S.-Mexico-IAEA study group that showed it would be technically feasible to install a large nuclear power-desalting plant on or near the Gulf of California to provide fresh water and electric power for arid regions of the southwestern United States and northwest Mexico.

Discussions were also held with several other nations interested in nuclear desalting, including Pakistan and Spain.

COMMERCIAL ACTIVITIES

Plans for the construction of U.S.-type light water reactors abroad continued at a brisk pace during the year with over 8,000 Mwe. of light water reactors ordered in 1969 in eight countries. For the most part, the principal suppliers of these plants will be foreign licensees of U.S. firms. In four countries, however, American suppliers will be the principal contractors for the nuclear steam supply system as a minimum. Enrichment services for all the installations are expected to be provided from the United States. The installed value of these plants will approach $2 billion.

Swiss and Indian Startups

With the startup of the NOK pressurized water (Westinghouse) nuclear powerplant in Switzerland and the Tarapur boiling water reactor (General Electric) station in India the total of U.S.-type nuclear powerplants operating abroad is now 10. An additional 11 light water reactors are under construction.

The completion and successful operation of the nuclear powerplant at Tarapur, India, made it the first such plant to become operational in a developing country. This 380-Mwe. boiling water, twin reactor powerplant is located 62 miles north of Bombay, on the Arabian Sea.

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The enriched uranium fuel for it is being supplied under a sales contract with the AEC.

Foreign Reactor Growth Projection

The AEC's present projection is that by the end of 1980, U.S.-type reactors with a power generating capacity of some 100,000 Mwe. will be installed abroad. The distribution among the largest users is estimated as:

Country	*AEC Projection (Mwe.)*
Belgium	3, 600
France [1]	4, 900
Germany	20, 500
Japan	18, 200
Italy	9, 900
Spain	4, 100
Sweden	8, 700
Switzerland	5, 400
All Others (21 countries)	21, 700
	97, 000

[1] It is not possible to predict the effect which the French Government's decision, made late in the year, to employ the U.S.-type light water reactors in their nuclear power program, will have on this projection.

Materials Supplied Abroad and Services Provided

The year 1969 marked the beginning of uranium toll enrichment services for overseas as well as domestic users (see "Uranium Enrichment" in Chapter 1—"Source, Special, and Byproduct Nuclear Materials"). Shipment of toll-enriched material was authorized starting January 1, and the first shipment was dispatched to European users on January 6. By the end of the year, 17 toll enrichment services contracts had been executed under agreements for cooperation with other countries. It is estimated that the AEC revenues over the terms of these contracts which are for periods of up to 30 years, will be about $400 million. Export shipments to cooperating countries totaled approximately 2,980 kilograms of uranium-235, under toll enrichment agreements, 4,466 kilograms of uranium-235 under sale and lease agreements, and 167 kilograms of plutonium.

As of mid-1969, the AEC had distributed abroad through sale, lease, and deferred payment sales, special nuclear material and other materials to the approximate value of $360.9 million, resulting in revenues to the AEC of $272.3 million. In 1969, the AEC negotiated the sale of 667 tons of heavy water valued at $35.4 million, for use as a coolant and/or moderator in power reactors in Argentina, Canada, and the Federal Republic of Germany.

The AEC continued to provide chemical reprocessing services for fuel irradiated in Canadian and Japanese reactors; 12 shipments of spent fuel were received from these countries for reprocessing. The AEC also assisted the U.S. Coast Guard in clearing one additional port to handle shipments of radioactive materials, bringing to 47 the total number of ports cleared to date.

As in the past, the AEC continued to make small quantities of scarce isotopes available to foreign users for research purposes.

Chapter 13

INFORMATIONAL AND RELATED ACTIVITIES

ATOMIC ENERGY FILMS

The showing of atomic energy films by schools, public groups, industrial organizations, and television stations continues to increase. The AEC's 11 domestic film libraries[1] and nonprofit sub-libraries loaned popular-level and professional-level films on atomic energy for 101,092 showings. During the year 17 new motion pictures were added to the film library system.[2] AEC films were also used on foreign television, at international exhibits, and were circulated by AEC and USIA libraries abroad.

1969 Film Showings

Stocked with 11,161 prints of popular and professional-level films the AEC's 11 domestic film libraries, nonprofit sub-libraries, and foreign libraries loaned films which were viewed by an estimated 4,345,000 persons in public schools, institutions of higher learning, industrial organizations, scientific and engineering groups, service clubs, and other community groups.

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[1] A new AEC film library was installed at the University of Alaska during the year.

[2] Descriptions of films available for public showings are included in the "Popular-Level" and "Professional-Level" film catalogs available, without charge, from Director of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545. The AEC's domestic film libraries located at the following AEC offices serve requests from the indicated States: Washington, D.C.: Delaware, District of Columbia, Maryland, Virginia, West Virginia, and Canada; New York, N.Y.: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; Aiken, S.C.: Alabama, Florida, Georgia, North Carolina, and South Carolina; Idaho Falls: Idaho, Montana, and Utah; Berkeley, Calif.: California, Hawaii, and Nevada; Grand Junction, Colo.: Colorado, Kansas, Nebraska, and Wyoming; Argonne, Ill.: Illinois, Indina, Iowa, Michigan, Minnesota, Missouri, North Dakota, Ohio, South Dakota, and Wisconsin; Oak Ridge, Tenn.: Arkansas, Kentucky, Louisiana, Mississippi, and Tennessee; Albuquerque, N. Mex.: Arizona, New Mexico, Oklahoma, and Texas; and Richland, Wash.: Oregon, and Washington. (See Appendix 1 for addresses of offices.)

International Aspects

Loans of more than 7,000 motion pictures, largely on a professional level, were made from AEC liaison offices in London, Tokyo, Brussels, and Buenos Aires, the latter two libraries supplying French and Spanish versions of many of these films. The use of AEC films by foreign scientific, industrial, and educational organizations increased during 1969 with Australia, Canada, Israel, and The Netherlands leading the list.

AEC motion pictures were used in "Atoms-in-Action" Nuclear Science Demonstration Centers in Sao Paulo, Brazil; Manila, the Philippines; Bucharest, Romania; Rassegna Nucleare and the Pur-aqua Exhibit-Conference, Rome, Italy. Special duplicating materials of AEC films were provided to the U.S. Information Agency (USIA) for making French, Spanish, Portuguese, Persian, Romanian, Mandarin, and Arabic versions of selected titles. These versions were used by AEC foreign exhibits, the International Atomic Energy Agency (IAEA) for worldwide film loans, and U.S. Embassies.

In addition, foreign as well as English-language versions were supplied to the National Science Film Library of Canada in Ontario, the American Film Library at The Hague, the IAEA film library in Vienna, to the USIA service offices in Stockholm and Brussels, to the U.S. Agency for International Development (AID) film libraries in Mexico City, Paris, and Washington, D.C.

Thirteen AEC films were entered in 28 different international events. Some received special honors, such as: a "Particular Merit" award for "Brookhaven Spectrum" at the 6th International Labour and Industrial Film Triennial, Antwerp, Belgium; the "Golden Eagle Award" to "Combustion Techniques in Liquid Scintillation Counting" by the Council on International Non-Theatrical Events (CINE), Washington, D.C.; "Finalist" awards to "No Greater Challenge" and "Radiation Accident Patients" by the Industrial Photography Film Awards, New York City; and "Guardian of the Atom" was selected for showing in 22 cities for a series of National Security Seminars under Industrial College of the Armed Forces sponsorship.

Atomic Energy on Television and Radio

AEC films were widely used on domestic and foreign television. Three films: "The Atom: Year of Purpose," "No Greater Challenge" and "The Warm Coat" had special TV campaigns. Audiences, estimated at 23-million, viewed many AEC films through 276 reported showings on educational and commercial TV channels. Many network and large-city station programs and producers were provided footage, photographic assistance, interviewees to answer critics and help present the atomic energy story. In addition, Japanese and German TV producers were supplied with stock footage, information, and filming opportunities.

The first of a new series of radio programs, "Seaborg on Science," a record of ten 3½-minute programs, was sent to 1,200 commercial and educational broadcasting stations in the United States and Canada.

Atomic Energy Photographs and Slides

An AEC color slide and transparency library, representative of a broad range of AEC activities, is being developed along with an updated collection of black and white news photographs. Slides are made available [3] to science teachers for lectures, AEC and contractor speakers as visual aids. Color transparencies and black and white photographs are supplied on request [3] to the magazine and news media, encyclopedias, educational publishers, science writers, exhibits, and reports.

TECHNICAL INFORMATION

Progress was made toward the inauguration of the International Nuclear Information System and in the development and strengthening of advanced methods for disseminating scientific and technical information to diverse domestic audiences.

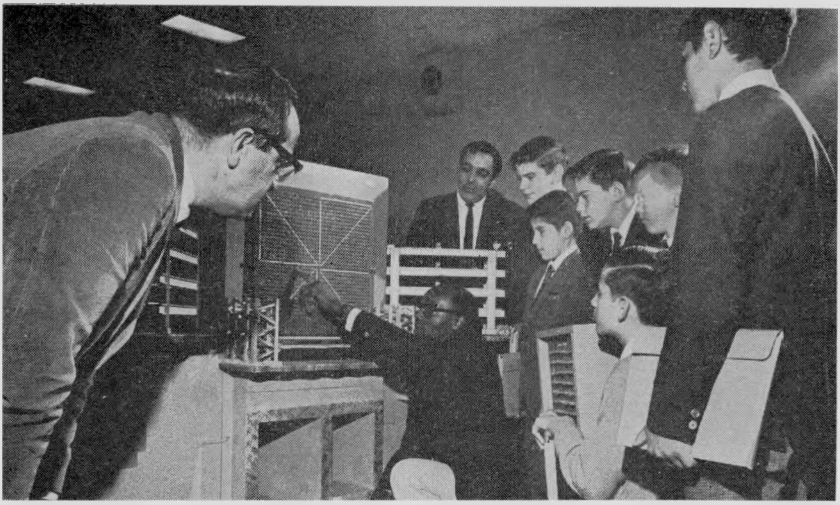
INFORMATION SERVICES

The AEC continued to employ a variety of methods for communicating information about nuclear energy to the scientific and educational communities and to broader public audiences in this country and overseas.

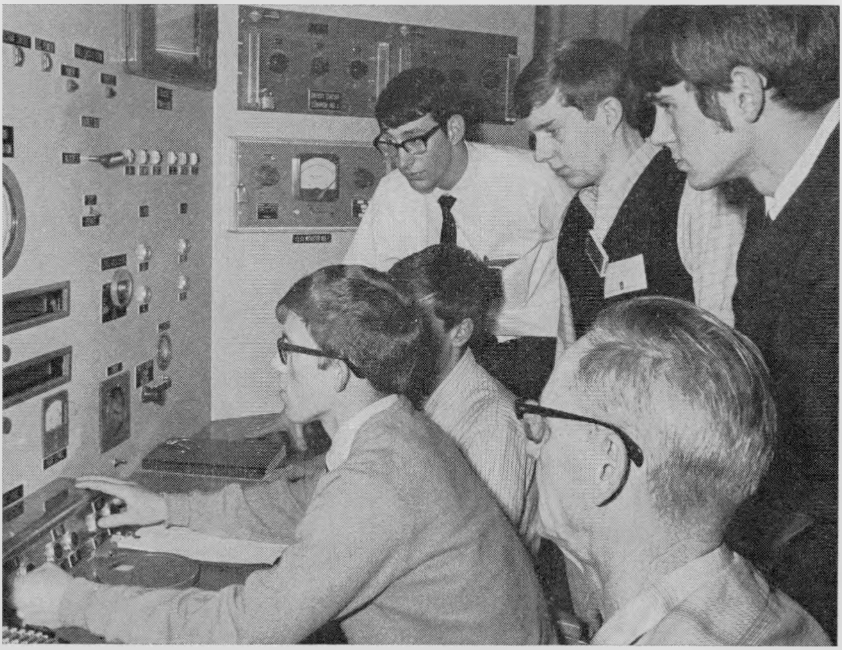
International Cooperation

The International Atomic Energy Agency (IAEA) requested, and was provided, expert documentation assistance from member nations

[3] From Director of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.



Firsthand Experience Helps Students bridge the gap between theory and practice. More than 5,000 high school students visited 16 AEC-contractor plants and laboratories on the 13th annual Science Youth Day which commemorated the February birthday of Thomas Alva Edison. At Brookhaven National Laboratory they toured the Graphite Research Reactor facility after an explanation based on a model (*above*). Science students (*below*) paid rapt attention as they operated, under supervision of a Douglas United Nuclear technician, the Hanford Test Reactor—now the world's oldest operating reactor and used for nuclear purity tests on reactor materials.



to help define the subject fields for coverage by the planned International Nuclear Information System (INIS). The system, as approved by the IAEA Board of Governors, will eventually cover a broad range of subjects related to nuclear energy. However, when INIS first becomes operational in early 1970, its subject scope will be restricted to reactor technology and engineering. Under INIS, member countries will supply the IAEA with bibliographic descriptions, abstracts, and indexing of their own current nuclear literature. Based on this input from members, IAEA will prepare a complete data file, make it available to members on magnetic computer tape, prepare categorized listings, and furnish copies of reports on request.

Distribution of AEC Technical Reports

The AEC discontinued its free distribution of microfiche copies of its scientific and technical reports in favor of a contractual arrangement whereby the National Cash Register Co.'s, Oak Ridge, Tenn., facility was authorized to sell the microfiche at special rates to certain classes of customers. AEC reports are also sold to the general public by the U.S. Clearinghouse for Federal Scientific and Technical Information (Springfield, Va. 22151); and to purchasers abroad by the National Lending Library at Boston Spa, Yorkshire, England, and the International Atomic Energy Agency in Vienna, Austria.

Conferences

During 1969, the AEC supported 14 scientific and technical conferences sponsored by U.S. organizations. In addition, the AEC coordinated the U.S. participation in 11 conferences sponsored by the International Atomic Energy Agency. Conferences such as those supported by the AEC make a significant contribution to U.S. research and development in the opportunity they afford for formal and informal communication among scientists with common interests.

Publishing Activities

Scientific and Technical Volumes

The *Critical Review Series*, begun in 1969, provides scientists and technologists with a compact synthesis and evaluation of the existing knowledge in a specific field, thus freeing them from the necessity of scanning a large body of original literature. Three volumes in the series were issued during the year. The AEC also published five new titles in its technical book series, four monographs in cooperation with scientific societies, and five volumes in the symposium series. (For complete list see Appendix 7.)

Technical Progress Reviews

The American Nuclear Society (ANS) assumed responsibility for preparation of in-depth critical reviews for *Reactor Technology*, one of the AEC's four Technical Progress Reviews.[5] This journal replaced *Reactor and Fuel-Processing Technology*, formerly prepared by Argonne National Laboratory. The ANS-prepared reviews will be supplemented by articles submitted by private consultants and material prepared by the AEC staff.

Educational Booklets

Specialized subject booklets, designed for use by various age levels, provide an effective and economical means for responding to the large number of inquiries on scientific subjects received by the AEC each year from students and teachers. The booklets are also used as supplementary instructional materials.

Work began on "The World of the Atom," a new series of booklets which will offer instruction on nuclear energy to elementary school science students and teachers. The first booklets in this series will be published in 1970.

Three new booklets were added to the AEC's "Understanding the Atom" series (see appendix 7), bringing the total now available to 53. Though intended primarily for secondary school science students and teachers, the booklets are also popular with elementary school and college students and teachers, and with the general public. Since the series was begun in 1962, over 8 million copies have been distributed. Some of the booklets have been translated into several foreign languages, and seven are printed in Braille and distributed through the American Printing House for the Blind, Louisville, Ky.

Other Services

The AEC encourages industry to make commercial use of innovations generated in its research and development programs. "AEC/

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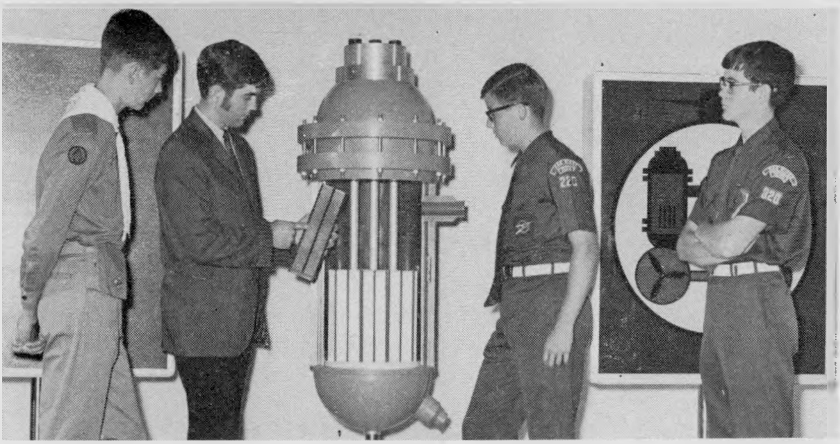
[5] Technical Progress Reviews may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at the following prices: *Nuclear Safety*, $3.50 per year (six issues), $0.60 per issue; *Reactor Technology*, $3 per year (four issues), $0.75 per issue; *Isotopes and Radiation Technology*, $2.50 per year (four issues), $0.70 per issue; and *Reactor Materials*, $2.50 per year (4 issues), $0.70 per issue.



About 15,000 Boy Scouts have qualified for the award since the first Atomic Energy Merit Badge was presented by AEC Chairman Seaborg in the mid-1960's. In photo *above*, a teacher-demonstrator at the Oak Ridge Associated Universities counsels candidates on one of the requirements for the Atomic Energy Merit Badge by explaining the intricacies of a nuclear reactor with the aid of a mock-up reactor core which can be taken down and reassembled. The Scouts must qualify for the badge by building models of nuclear equipment and satisfactorily demonstrating a familiarity with nuclear terms and concepts. Many of the estimated 50,000 Scouts and adult Scouters at the Boy Scout National Jamboree held this past summer at Farragut State Park, Idaho, visited the special AEC exhibit "This Atomic World" (shown *below*). The exhibit, which featured a lecture-demonstration on nuclear energy, emphasized its role in preserving America's natural environment and provided assistance to Scouts interested in earning the Merit Badge in Atomic Energy.

NASA Tech Briefs" describing 35 such innovative developments were published during the year.[6]

Information and data centers, supported wholly or in part by the AEC, furnish to scientists and engineers data compilations, analyses, and other information in specialized subject fields. A booklet listing these centers is available.[7]

DEMONSTRATIONS AND EXHIBITS

The AEC's demonstrations and exhibits continued to play a significant role in providing information on peaceful uses of nuclear energy. Some 6.3 million U.S. viewers were attracted to these presentations in 1969. In the important secondary school program, a majority of the lecture-demonstration units were operated by State-sponsored organizations in a cooperative program with the AEC. A new circulating museum exhibit, "Energy," had its premier showing during 1969. Five major presentations were made overseas, including a nuclear science demonstration center in Romania, the first such presentation in Eastern Europe in 6 years.

Presentations in the U.S.

In 1969, "This Atomic World" lecture-demonstrations were shown to 2.5 million students and their teachers in approximately 3,000 secondary schools in 38 States. During the 1969–70 school year, six of the 23 units are being operated for the AEC by Oak Ridge Associated Universities (ORAU). The 17 others (an increase of seven over the 1968–69 school year) are operated under cooperative agreements with State-sponsored organizations (see Appendix 7) which furnish the teachers and schedule the presentations; the AEC supplies the van and demonstration equipment, and trains the teachers. The State sponsors include universities, colleges, and atomic development agencies, many of which have received grants in support of the program from utilities and other business groups.

The program's contributions were recognized by the Atomic Industrial Forum, which, in December 1969, presented to ORAU the annual Forum award for significant contributions to the public understanding of atomic energy. The award citation pointed out that during its first 10 years of operation, "This Atomic World" had been presented

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[6] Available at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. 22151.

[7] From Director, Division of Technical Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

to more than 16 million students in some 19,000 high schools in all 50 States.

Circulating Museum Exhibits

"Energy," a new unit developed specifically for extended engagements in large museums, made its premier appearance early in 1969 at the California Museum of Science & Industry in Los Angeles, and in the fall became a feature attraction at San Francisco's newly opened Palace of Arts and Science. "Radiation and Man" was presented in Milwaukee for 5 months, at the Science Museum in St. Paul, and at the Pacific Science Center in Seattle. "Life Science Radiation Laboratory" operated at the Fort Worth Museum of Science and History, then moved on to the New York Hall of Science. During 1969, these exhibits were viewed by more than a million museum visitors.

Halls of Science

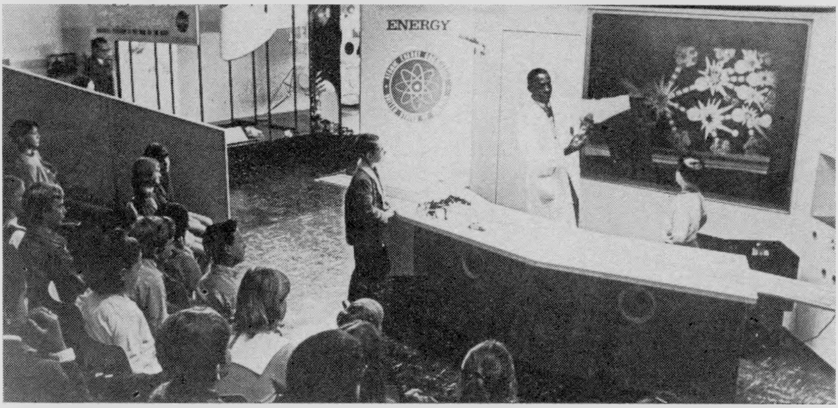
The AEC agreed to support installation of a nuclear reactor and a gamma radiation facility in a new structure being added to the New York Hall of Science. The nuclear facilities will be used for instruction and research by colleges in the area, as well as for public demonstrations.

A new exhibit, "Radiation at Work," opened in November at the Chicago Museum of Science and Industry, where the AEC has maintained exhibits since 1955. Designed by ORAU and fabricated under the direction of Argonne National Laboratory, which manages AEC's Chicago exhibit, "Radiation at Work" depicts uses of radiation in medicine, agriculture, and industry.

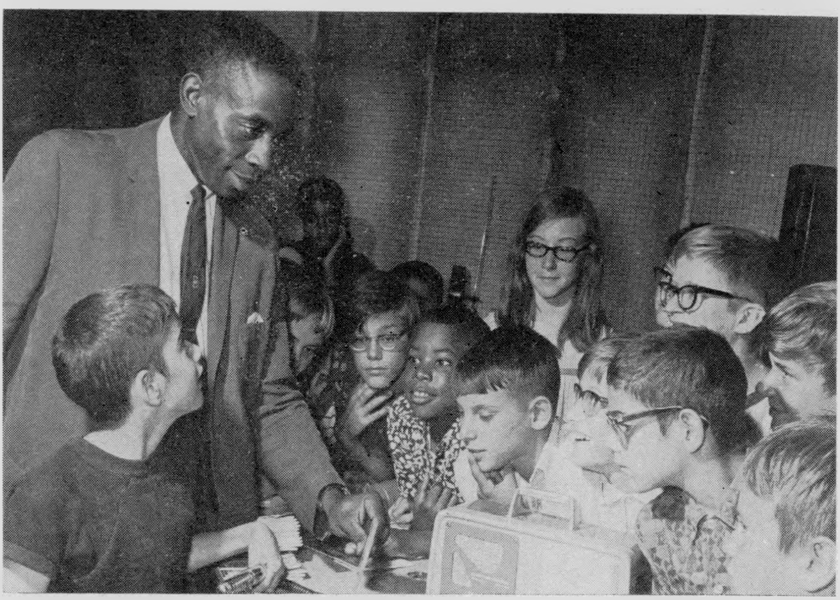
During the week-long Boy Scouts of America National Jamboree held in July at Farragut State Park, Idaho, some 10,000 scouts and adult leaders viewed a special AEC lecture-demonstration emphasizing the contributions of nuclear science and technology to conservation of national resources. A special "Nuclear Energy in Space" exhibit, prepared for the Aerospace Fair at the 1969 California Exposition in Sacramento, featured nuclear rocket research plus isotopic generators and small reactors designed specifically to supply dependable long-lived power for space missions.

Presentations Abroad

"Atoms in Action" Nuclear Science Demonstration Centers were presented in Manila, Philippines (Feb. 15 to Mar. 16); in Bucha-



Part of the New AEC Exhibit—"Energy"—which is designed specifically for extended presentations at major U.S. museums, is shown in the photo *above* as it was situated in the San Francisco Palace of Arts and Sciences. A visiting school group watches David N. Jenkins, the teacher-demonstrator, as he explains how the energy of fissioning uranium atoms is released and controlled in the nuclear reactor. After a five-month stay in Milwaukee, Wis., with the AEC exhibit "Radiation and Man." Mr. Jenkins, from Oak Ridge (Tenn.) Associated Universities, received a citation from the Milwaukee City Council for his extracurricular activities involving city schools, civic clubs, and Boy Scout Troops which he undertook after his regular lecture demonstrations at the AEC exhibit. The Milwaukee citation, in turn, resulted in his receiving a commendation from AEC Chairman Seaborg. In the photo *below*, Mr. Jenkins is shown with one of the notable extracurricular classroom sessions in progress.



rest, Romania (October 1–28); and in Sao Paulo, Brazil (Oct. 17 to Nov. 16).

The presentation in Romania was the first in Eastern Europe since "Atoms in Action" visited Yugoslavia in 1963. During the month-long showing, more than 90,000 Romanians visited the facility; and others heard American scientists lecture at universities and educational institutions. At the close of the center's visit, the AEC-owned 10,000-curie cobalt-60 gamma facility was transferred to the Romanian Committee for Nuclear Energy on an extended-loan basis. The Romanians also purchased over $100,000 worth of U.S. equipment demonstrated at the exhibit. In inaugurating the presentation, AEC Chairman Seaborg informed Chairman Horia Hulubei of the Romanian Committee for Nuclear Energy of the latter's election to fellowship in the American Physical Society.

The Brazilian showing of "Atoms in Action" marked the first use of a new time-saving and cost-saving construction technique. Three semipermanent reinforced-concrete domes were constructed by a process which involves pouring concrete over an inflatable plastic envelope. Inflation of the envelope raises the still wet concrete into position, and helical steel reinforcing material holds the concrete in place. The success of this "Binishell" process at the Brazil exhibit will probably lead to its use at all future "Atoms in Action" presentations. The buildings will then be donated to the host countries, as was done in Sao Paulo, where they will be used as a science center.

A feature of "Atoms in Action's" stay in Manila was the 24-hour-a-day operation of the gamma irradiator, which permitted maximum use of the facility for food preservation experiments. A new course, developed by Argonne National Laboratory on measurement of radioisotopes by liquid scintillation counting methods was introduced at this Center.

Classroom training at "Atoms in Action" Centers is supervised by Oak Ridge Associated Universities. Lockheed-Georgia Nuclear Laboratories (Marietta, Ga.), staffs the reactor operations. Scientific staff members are provided by the AEC's Puerto Rico Nuclear Center for Latin American showings; and by Argonne National Laboratory for the Centers which visit Europe and Asia.

INFORMATION DECLASSIFICATION

A major function of the AEC classification program is the continuous review of information developed in AEC technical programs to insure maximum release of information without endangering the national defense and security. In meeting this objective, the AEC carefully considers information also developed by other countries as well as information developed in the United States to assure that its classification policy is both current and logical.

New Laser Classification Policy

A more definitive and less restrictive laser classification policy has been developed replacing a 1964 policy.[8] The new criteria classify, under the espionage laws, information concerning lasers or laser systems capable of power output of 100,000 joules or more in 10 nanoseconds (billionths of a second) or less. The previous criteria classified such devices with a total energy output of only 1,000 joules or more. Even though the information may be determined not to be classified under the espionage laws by the foregoing principles, it may still be classified under the Atomic Energy Act of 1954 if the lasers incorporate special nuclear material or if the application or the manner or method of such application involves: (*a*) The production of energy using special nuclear material which is not a part of the laser; (*b*) the production of special nuclear material; or (*c*) the design, manufacture, or use of atomic weapons.

Documents Declassified

During the year, some 10,000 documents were declassified. Most of the technical information declassified has been made available to industry and to the scientific community. The declassification review has also resulted in a reduction in the numbers of classified documents at several storage facilities thereby reducing the cost involved in the periodic surveillance of these documents.

Access Permits

The AEC's Access Permit Program continues to be used to provide classified information to individuals for civilian applications of atomic energy. On November 30, 1969, there were 349 Access Permits in effect: 283 for access to Secret Restricted Data, and 66 for access to Confidential Restricted Data, as compared to 304 for Secret, and 71 for Confidential a year earlier.

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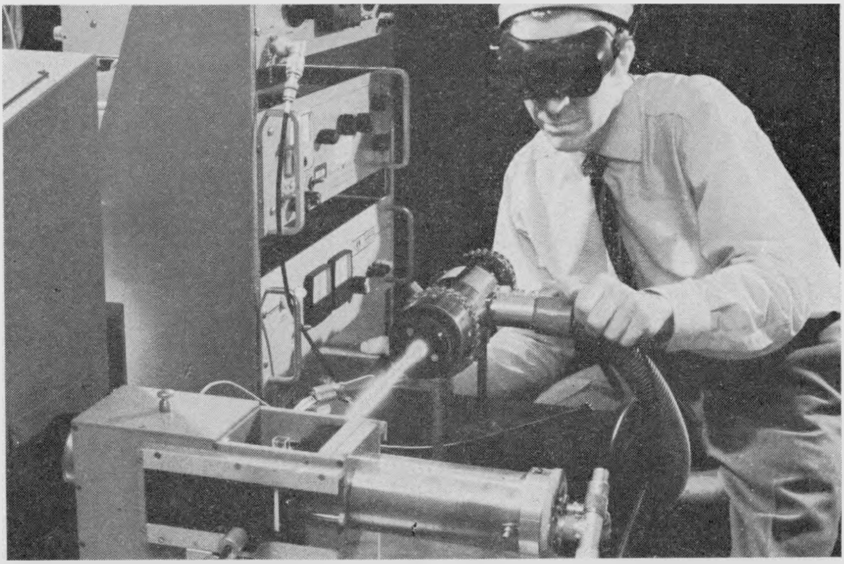
[8] See p. 297, "Annual Report to Congress for 1964."

Ever-Brodening Uses of Laser Beams were enhanced during 1969 when a more definite and less restrictive classification on laser information was adopted. In photo *above*, a low-power transit laser is used to align drift tubes of the Alternating Gradient Synchrotron at Brookhaven National Laboratory. Lasers are still in their first decade of use in such things as medical surgery, space communications, photography, mining, electronics, the security field, and scientific research. Air pollution studies are now being conducted at Brookhaven by use of a relatively high power pulsed laser to obtain information on atmospheric contaminants. In photo *below* bright flashes from a ruby laser are used in studies of photosynthesis in the Brookhaven biology department where a suspension of chloroplasts isolated from spinach leaves is illuminated in a flat-sided glass vessel. A photomultiplier tube, center foreground, senses absorbance changes in the pigments of the photosynthesis apparatus. The results may tell how plants use electrons in converting carbon dioxide to sugars.



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PATENT INFORMATION

The availability of AEC-owned U.S. and foreign patents for licensing is publicized in technical journals and through AEC news releases.[9]

1969 Issuances

The AEC was granted 267 U.S. patents during the period November 19, 1968, to November 18, 1969, which brings the total number of unexpired U.S. patents available for licensing to 4,197. The AEC acquired 302 additional foreign patents in some 15 countries during the year and the portfolio of foreign patents is now 4,242.

The AEC granted 106 nonexclusive licenses on Government-owned patents and patent applications. In addition to those licenses granted by the AEC, 27 nonexclusive licenses have been retained by contractors. Exclusive licenses in fields other than atomic energy have been retained by AEC contractors in 18 patents. The AEC has been granted nonexclusive licenses for governmental purposes in 19 patents to which contractors have retained title.

Private Atomic Energy Applications

Under the provisions of the Atomic Energy Act of 1954, as amended, the Commissioner of Patents referred 646 privately owned U.S. Patent applications for review by the AEC. A total of 48 directives was filed with the Commissioner of Patents by the AEC with respect to the question of rights which brings the total number of directives filed under Section 152 to 296. The AEC has acquired rights in 147 Section 152 applications, and in 96 cases the directives were withdrawn without acquisition of rights after completion of investigations, and two cases were abandoned. Some 51 applications are pending.

Compulsory Licensing Hearing

The authority of the AEC to compulsory license pursuant to Section 153 of the Atomic Energy Act terminated as of September 1 with respect to patents, the applications for which had been filed on or before September 1. The AEC requested extension to September 1, 1974; and congressional hearings were held and an omnibus bill including extension of the compulsory licensing section was reported out by the Joint Committee on Atomic Energy.

[9] Listings published as AEC public announcements (available from Division of Public Information, U.S. AEC, Washington, D.C. 20545) during 1969: No. M–28 (Italian Patents), February 5: No. M–63 (U.S. Patents), March 12; No. M–123 (U.S. Patents), May 22; No. M–172 (U.S. Patents), July 25; No. M–245 (Canadian Patents), October 27; No. M–254 (U.S. Patents), November 10.

Chapter 14

NUCLEAR EDUCATION AND TRAINING

GENERAL TRAINING ACTIVITIES

The AEC's education and training mission seeks to assure an educational structure capable of training a variety of individuals at the associate, bachelor, master, doctoral, and postdoctoral levels in engineering and scientific disciplines needed in nuclear activities, as well as attracting students into the pertinent nuclear disciplines and academic levels. The AEC also provides specialized *ad hoc* courses as demands require for retraining or upgrading of personnel already employed in nuclear activities. To accomplish these goals, data on manpower supply and demand is gathered, analyzed, and disseminated to educational organizations, employers, and prospective students.

Manpower Study

A survey has been initiated to assess the foreseeable manpower, education, and training requirements in the nuclear field and the adequacy of programs to meet such needs. The survey is being conducted for the AEC by the American Nuclear Society in cooperation with the American Society for Engineering Education. The survey includes universities and a representative sampling of companies in the nuclear industry. Collection of data for the university-portion was by means of a questionnaire sent to 269 institutions, approximately 68 percent of which were completed and returned. Data for the industry segment was collected through in-depth interviews with representatives of 70 companies in the nuclear field. As of September 1969, industry data collection had been completed. The analysis, correlation of the data with previous surveys by the Bureau of Labor Statistics, and the interrelation of the two portions of the survey are expected to be completed by February 1970.

Nuclear Power Utility Staffing

The work of an AEC Utility Orientation Task Force has resulted in a publication entitled "Utility Staffing for Nuclear Power." [1] The publication contains the task force's findings on staffing requirements; individual job qualifications; typical education, training, and experience schedules; and sources of trained manpower. It also contains the gleanings of the task force on the availability of pertinent training programs available from colleges and universities, reactor manufacturers, utilities, labor unions, consultants, Federal agencies and technical institutes. It is intended to help utility management locate training programs required for upgrading their staffs as they move into nuclear power, to suggest sources of new employees, and to suggest to other educational institutions the type of training needed by people who are attracted into the growing nuclear power industry. Typical staffing organizations for utility headquarters and nuclear central power stations are also shown in the report, as well as estimates of utility manpower needs through 1976.

Nuclear Engineering Careers

To interest young students in nuclear engineering as a career, the American Society for Engineering Education with AEC support has published an informative booklet.[2] It reviews some of the ways in which nuclear engineers will help face the challenges of tomorrow. Among the areas treated are: industrial power, space exploration, water supply, food supply, environment and pollution, health, and transportation.

Film Production. Films are an excellent way of attracting and motivating young students into careers in specialized fields. The AEC financed a joint effort by the American Nuclear Society and the Army Pictorial Service which resulted in three films on nuclear careers for viewing by high school and junior high school students: "Horizons Unlimited," "Your Place in the Nuclear Age," and "Preparing for Tomorrow's World." [3]

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[1] "Utility Staffing for Nuclear Power"—available from U.S. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 at $0.75 a copy.

[2] "Nuclear Engineering In Your Future," available from ASEE Publication-Sales, 2100 Pennsylvania Ave., N.W., Washington, D.C. 20037 at $0.50 each or $0.35 each when bought in lots of 100 or more.

[3] Available from AEC film libraries (see footnote 2, p. 215 in Chapter 13—"Informational and Related Activities").

UNIVERSITY-AEC LABORATORY PROGRAMS

Colleges and universities in the United States are afforded excellent opportunities to keep abreast of the rapidly changing technologies in the nuclear sciences and engineering through the AEC's laboratory cooperative programs. These programs enable faculty and student use of the AEC's extensive facilities when comparable facilities are not readily available on campus. During 1969, approximately 527 faculty and 2,076 students from 480 institutions in 47 States plus the District of Columbia availed themselves of these opportunities at 15 AEC laboratories.[4]

Summer Programs

Educational opportunities at AEC laboratories are made known to college and university faculty and students through: (*a*) Periodic announcements by the laboratories or related associations of colleges and universities, and (*b*) continuing direct communication between faculty and laboratory professional staff. Faculty and student research participation, faculty-student conferences and workshops, engineering practice schools, laboratory fellowships for thesis research, and educational conferences are the laboratory activities open to the educators. The faculty and student research participation programs are, for the most part, summertime programs. During 1969, these programs supported 148 faculty and 408 students at 15 AEC laboratories.

A 2-week faculty-student conference was conducted again at the Argonne National Laboratory in August 1969 with a total of 61 faculty and 120 students participating from 54 institutions in 28 States. Presentations of the latest information on plasma physics and controlled fusion, power reactor concepts, nuclear energy in space exploration, and environmental aspects of nuclear power were featured.

Engineering Practice Schools

Engineering practice schools were supported in 1969 at the Argonne and Oak Ridge National Laboratories. The practice schools provide graduate students with real engineering experience on actual current problems at the laboratories. The one at Argonne was a summer-long session with 25 students participating. At Oak Ridge, two enginering

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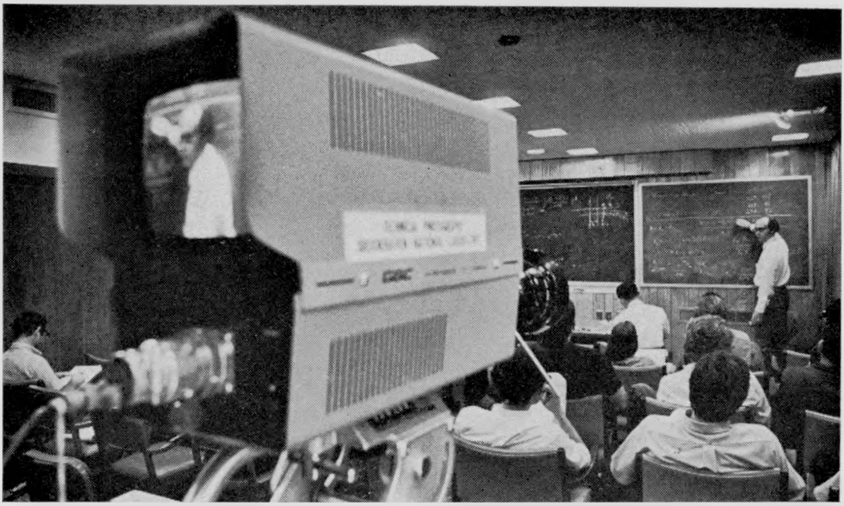
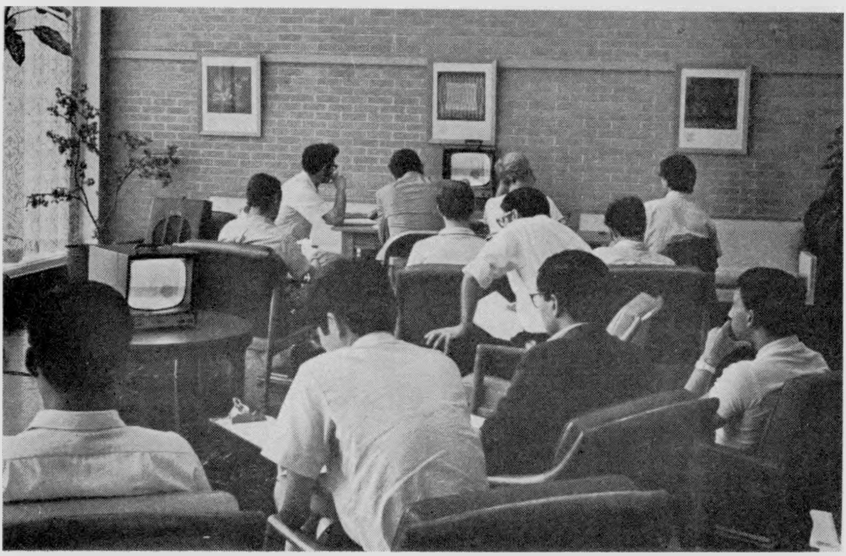
[4] Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, E. O. Lawrence Radiation Laboratory (Berkeley and Livermore), Los Alamos Scientific Laboratory, Lovelace Foundation, National Reactor Testing Station, Oak Ridge National Laboratory, Pacific Northwest Laboratory, Puerto Rico Nuclear Center, Sandia Laboratory, Savannah River Laboratory, Stanford Linear Accelerator Center, and University of Rochester Atomic Energy Research Project.



Closed Circuit TV in the Classroom reinforced the Brookhaven "Summer School for Elementary Particle Physics." Lectures were given "live" at 9 and 11 each morning (shown *above*) with two TV cameras and over 20 registered students in attendance. The lectures are transmitted simultaneously to the lounge (shown *below*) where nonregistered students can hear and see the lecture without entering the classroom. Also recorded on video tape, the lecture is played back in the afternoon so that those who were unable to attend the morning sessions will not miss any of the subject matter. Many of the registered students use the afternoon rebroadcast for note-taking and clarification of the morning lectures. The summer school, sponsored by the Brookhaven National Laboratory physics department had a faculty of seven. The 21 students were selected from 150 applicants; most were graduate students in their second or third year of graduate studies.



practice schools were conducted during the academic year; one in chemical engineering administered by Massachusetts Institute of Technology, and the other, covering several engineering disciplines, administered by the University of Tennessee together with the Oak Ridge Associated Universities. There were 32 students in the two Oak Ridge practice schools in 1969.

Availability of Used Equipment

In June 1969, the AEC announced a new program of granting to U.S. colleges and universities, for educational purposes only, used nuclear-type laboratory equipment no longer needed by the AEC. The responsibility to locate such equipment and prepare the necessary proposals resides with the school faculty; proposals will be sent, through the cognizant laboratory, to AEC Headquarters for appropriate action.

Puerto Rico Nuclear Center

During 1969, progress continued in the development of the Puerto Rico Nuclear Center (PRNC) and included: (*a*) An expansion and upgrading of the physical facilities at both the Rio Piedras and Mayaguez sites; (*b*) an increased impact of PRNC professional talent on worldwide science, as expressed in the number of papers presented by PRNC staff at professional meetings around the world; (*c*) the increased number of consultations held with Latin Americans, wherein the research and educational opportunities at the center were described, hopefully leading to cooperative ventures; and (*d*) breaking the cost-of-living barrier for Latin American students at PRNC by arranging part-time employment opportunities.

The biomedical building at Rio Piedras has been expanded, at a cost of $1.4 million, to alleviate the serious overcrowding at that facility. At the Mayaguez site, the research reactor is being upgraded from 1 megawatt steady state to 2 megawatts, with pulsing capabilities up to 2,000 megawatts.

Approximately 50 students from 22 foreign countries were at the center during 1969 in addition to 149 U.S. citizens. Of the 50 students from foreign countries, 41 were from Latin America.

COLLEGE AND UNIVERSITY PROGRAMS

Through the AEC's nuclear science and engineering traineeship and fellowship programs, outstanding graduate students who are U.S. citizens are encouraged to continue their education to the masters, doctoral, and postdoctoral level. Fellowships are competitively awarded to students expressing their intention to teach or otherwise remain within the field of their proposed fellowship studies. Traineeships, on the other hand, are competitively awarded by quotas to universities, which then select promising graduate students to receive this assistance.

As of November 15, 1969, current fellowships and traineeships, including extensions, had been awarded as follows: nuclear science and engineering, 223; traineeships in nuclear engineering, 161; laboratory graduate fellowships, 125; postdoctoral fellowships, 40; health physics fellowships, 73; and industrial medicine fellowships, 8.

Institutes

In addition to AEC-sponsored faculty training institutes on subjects or levels suited solely to its mission, the AEC and the National Science Foundation cosponsor faculty training institutes at colleges and universities as equitably as possible across the country. There are four types of institutes: (*a*) Summer sessions of 5–8 weeks; (*b*) academic-year sessions for full-time study; (*c*) short topical programs of less than 28 days duration; and (*d*) inservice sessions offered weekly during the school year. All faculty training institutes are conducted in specialized nuclear subjects at the graduate level, and nearly all (except short topical conferences) may provide graduate academic credit. Approximately 25 percent of the science teacher participants already have earned their doctorates.

During the year, subjects such as radiobiology, nuclear physics, isotope technology, and radiochemistry were studied by more than 739 college and high school science teachers in institutes held at 28 colleges, at Argonne National Laboratory, and at the Oak Ridge Associated Universities.

Equipment Grants and Services

The AEC granted $491,559 to 61 colleges and universities during 1969 to purchase expensive laboratory equipment needed to enter or upgrade teaching of nuclear science and engineering. These grants were made on a 50-50 fund-matching basis. In addition, 22 grants totaling $13,000 were made for nuclear materials and radioactive sources.

During the year, 39 institutions were loaned nuclear materials, mostly in the form of plutonium-beryllium (Pu-Be) neutron sources, for use in neutron research. Reactor fuel assistance contracts totaling

$33,000 were approved with 10 institutions. The funds are for the fabrication of fuel elements to compensate for fuel burnup associated with the educational and education-related research use of the reactors.

A new reactor sharing program was instituted during the year to provide increased opportunities for colleges and universities to make use of reactors located at nearby universities. The objective of the program is to strengthen the nuclear science and engineering programs of institutions not having nuclear reactors. A pilot effort with two institutions at a total cost of $12,500 is currently underway. The University of California at Los Angeles and the Western New York Nuclear Research Center at Buffalo provide reactor services and technical assistance to universities within their area.

EQUAL OPPORTUNITY THROUGH EDUCATION

Despite the growing importance of scientific and engineering disciplines, decreasing proportions of undergraduate student bodies are oriented toward majoring in the technical areas of study. Helping minorities to overcome past educational disadvantages through involvement in AEC programs therefore has the result of strengthening atomic energy activities through a previously untapped manpower reservoir. During 1969, the AEC worked in a number of ways with predominantly Negro institutions. Among these efforts were:

(*1*) The Argonne National Laboratory summer program, where 14 Negro science undergraduates from 9 predominantly Negro institutions along with 32 white science undergraduates from 29 institutions were supported by AEC in research and training assignments at ANL for a period of 10 weeks;

(*2*) The "Brookhaven Semester Program" wherein a second group[5] of two Negro faculty and six Negro students selected from ten predominantly Negro institutions were supported by the National Science Foundation, with Brookhaven National Laboratory furnishing the research facilities, services, and related training in science. The students participate for one semester and the faculty members for an academic year. In September a third group, consisting of one faculty member and seven students arrived at Brookhaven.

(*3*) The Oak Ridge National Laboratory "Summer Science Program" employed 26 undergraduate students who were majoring in science, mathematics, or engineering at 10 predominantly Negro institutions for periods up to 13 weeks. Of the 44 university faculty members who were at the Oak Ridge National Laboratory as re-

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[5] See p. 19, "Annual Report to Congress for 1968."

search participants (at the expense of the AEC) during the summer, nine were from seven predominantly Negro schools.

Emerging Institutions Workshop

To help strengthen the six predominantly Negro institutions, the AEC supported a one-month "Workshop for Faculty of Emerging Engineering Institutions" conducted in August by the Oak Ridge Associated Universities. Attendees represented Howard University, North Carolina A & T, Prairie View A & M, Southern University, Tennessee A & I, and Tuskegee Institute, and occasionally other arts and science colleges. Detailed presentations on the AEC's education, training, research and development activities were given by representatives from AEC Headquarters. AEC field offices in Chicago, Oak Ridge, and Savannah River, Oak Ridge Associated Universities, Oak Ridge National Laboratory, Brookhaven National Laboratory, and Argonne National Laboratory. A one-day trip was also made to the Savannah River Laboratory. Presentations were also made by representatives of the National Science Foundation, U.S. Department of Health, Education, and Welfare, and of the National Aeronautics and Space Administration.

A major portion of the workship was devoted to planning for the design, development, implementation, and testing of a variety of processes for further strengthening of the six participating engineering schools. Some of these programs, in various stages of development, are:

(*1*) An announced pilot "Cooperative Education Program" involving Union Carbide Corp.'s Oak Ridge operations and the six institutions.

(*2*) Offering of an AEC depository library to Tuskegee Institute.

(*3*) Awarding of a research contract to North Carolina A & T from Union Carbide Nuclear Division, with four other research proposals still under consideration.

(*4*) Three workshops for the summer of 1970, involving most of the predominantly Negro institutions. A proposal for combined support has been submitted to the AEC, Department of Health, Education, and Welfare, and the National Science Foundation.

(*5*) Appointment of liaison representatives to the AEC and Oak Ridge Associated Universities at seven Negro institutions.

(*6*) A proposal for substantial financial support to the six engineering institutions from private corporations is in final development. Personnel from the AEC, Oak Ridge Associated Universities, and Union Carbide Nuclear are assisting in planning for this effort.

(7) Discussions of special programs utilizing the "This Atomic World" exhibit and the Mobile Radioisotope Laboratory.

Probably the most effective and immediate result of the program was a greater awareness among both the institutions and the various Federal and contractor representatives of the potential for greater cooperative activities leading to further strengthening of the contribution of these Negro institutions to the national manpower pool in engineering and science.

Chapter 15

BIOMEDICAL AND PHYSICAL RESEARCH

BIOLOGY AND MEDICINE

The overall goal of the AEC's biological, medical, and environmental research program is to develop the scientific knowledge needed for full comprehension of possible short- and long-term consequences of the interaction of radiations with biological systems, with emphasis on overcoming the attendant hazards of nuclear energy and exploiting the useful potentialities of radiation in the life and environmental sciences.

The year saw a realignment of the total biomedical research program to meet new and current requirements for identifying areas urgently in need of attention. For presenting the AEC's biomedical program budget to the Congress, the AEC-sponsored work will, hereafter, be presented in three major categories: Interaction of radiation with biological systems; assessment, evaluation, and control of radiation exposure to man and his environment; and beneficial applications of radiation.

Research in the biomedical program is carried out under more than 630 contracts. These contracts support work at nearly 225 universities, commercial research organizations, nonprofit institutions, and other Federal agencies; however, most of the work is performed at AEC national and other laboratories.

RECENT ADVANCEMENTS

Highlights of recent and interesting findings of the biomedical research program are included here. These, and other findings, are described more fully in Part 1 of the supplemental report "Fundamental Nuclear Energy Research—1969."[1] The supplemental report includes two feature sections covering AEC-sponsored human radiobiology studies and molecular genetics research.

Selected Beneficial Applications

● Patients with Parkinson's Disease (a shaking palsy) have received relief of their symptoms through a new treatment—L-Dopa. The medication is being made available to a number of medical centers throughout the country for continued evaluation of the benefit these patients may gain. Many already have been helped greatly.

Cancer Research

● Gallium-67 has an unusual affinity for certain soft tissue tumors making it a promising adjunct for detecting tumors by radioisotope scanning equipment. In addition, it has shown promise as an aid for radiation therapy for patients with Hodgkin's disease and lymphosarcoma. It is also being tested in selected patients with other kinds of cancer, and although some tumors show promising localization, other tumors fail to take up the radioisotope.

● Recent work has begun to provide some answers to the question of the nutritional needs of leukemic cells. Such requirements, if characteristic of certain cancer cells, could provide a means of truly selective cancer therapy. Theoretically, it should be possible to starve the cancer cells without harming the normal cells since normal cells are able to synthesize the denied nutrient.

● Extracts of tissues from seven of 55 human patients with bone cancer (osteosarcoma) have been used to induce a total of ten bone cancers in hamsters. Since there are only two known cases of spontaneous bone cancer in the hamster, the occurrence of ten cases in hamsters inoculated with these materials indicates the presence of an agent in human bone cancer that can induce a similar disease in hamsters.

Somatic Effects of Radiation

● The preliminary results of a study demonstrate little difference in relative biological effectiveness between protons and X-rays for any of the effects investigated. These studies are of interest to the National Aeronautics and Space Administration since protons com-

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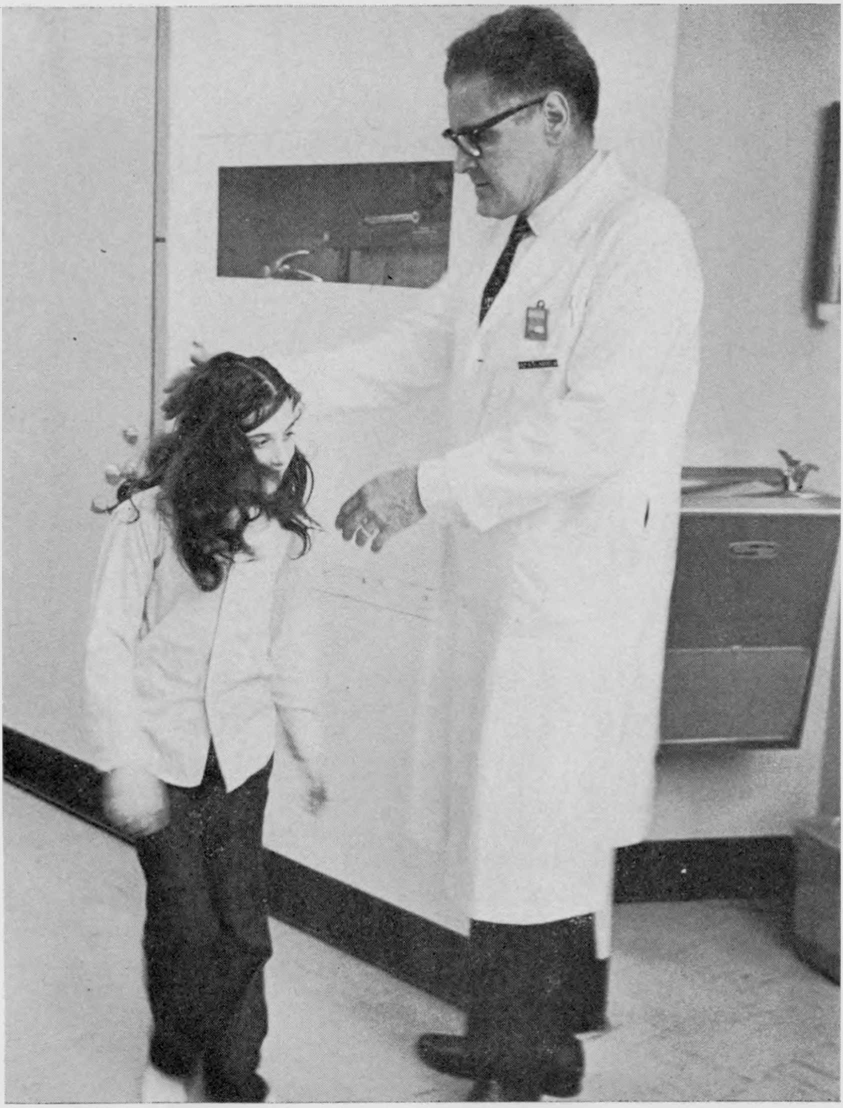
[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3.75.

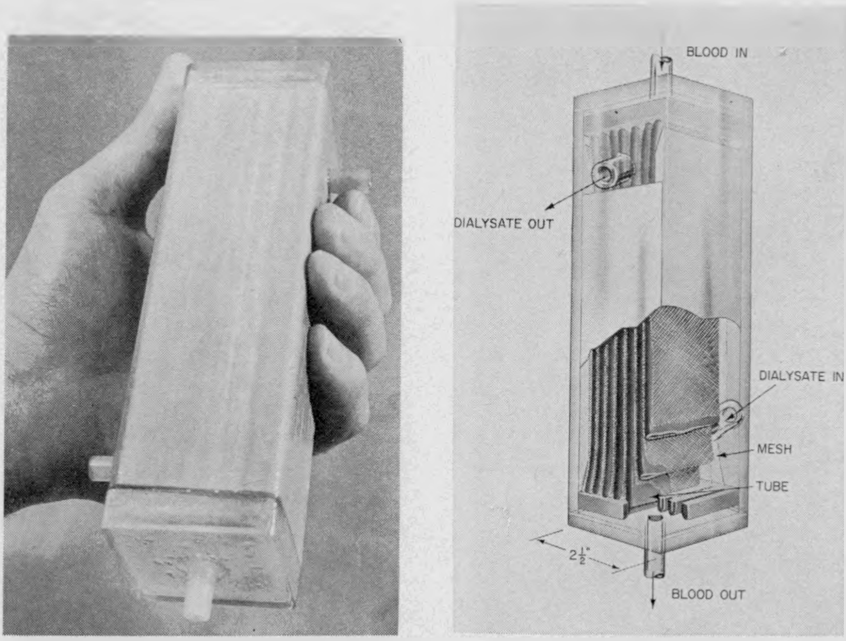


The 1969 Albert Lasker Award for Clinical Medical Research was made to Dr. George C. Cotzias, head of the physiology division at Brookhaven National Laboratory, for his demonstration of the effectiveness of large daily dosages of L-Dopa in the treatment of Parkinson's Disease. He is shown *above* evaluating the improvement induced by L-Dopa in a patient suffering from a form of shaking palsy which afflicts children. The award citation stated, in part: " . . . The remarkable contribution of Dr. Cotzias and his colleagues is the dramatic demonstration that large, daily dosages of L-Dopa can reverse most of the crippling effects of Parkinsonism." In an editorial in the New England Journal of Medicine, the work is called "The most important contribution to medical therapy of neurological disease in the past 50 years. . . ."

prise most of the radiations in the upper atmosphere and interplanetary space.

Human Radiobiology

- Persons with a measurable body burden of radium have characteristic defects and destructive changes in skeletal structure; skeletal tumors and other rare tumors of the tissues lining the mastoid bone, paranasal sinuses, and oral cavity may also exist. A continuing study of a limited population of workers known to have had a considerable body burden of radium is supplying information on the effects of radiation on man in relation to radiation exposure.
- A technique for microscopic examination of miners' sputum has been developed to a level which has considerable promise as a screening and diagnostic procedure. A panel is studying uniform diagnostic



An Early Prototype Artificial Kidney (hemodialyzer) which may prolong the lives of many people afflicted with kidney disease has been developed at AEC's Argonne National Laboratory through an interagency agreement with the National Institutes of Health. The plastic mockup of the small, disposable patient-managed artificial kidney is shown in the photo at *left*. Schematic at *right* shows how the device filters the body waste products from the blood of patients whose own kidneys are diseased or nonfunctioning. The prototype dialyzer is 8 inches high, 2½ inches wide, and 2½ inches thick.

test criteria which may be useful for general medical application for detection of early (precancerous) changes in cells from the lining of the lung.

● Studies are being made in an attempt to evaluate the hazards of ingested and inhaled radioactive compounds in uranium miners and certain industrial workers by measuring the amount of radiolead in man. The results indicate that ingested radiolead is absorbed by the intestine and distributed throughout the body, whereas lead inhaled as dust tends to remain in the lung.

● The AEC has participated in the care of patients who were involved in a serious accident in a private industrial facility (radiation source exposure) in 1967. Every effort has been made to obtain information on infections following irradiation and factors related to resistance to infection. (One patient received bone marrow cells from his unexposed identical twin brother.) An interesting feature of the care and treatment was the use of laminar air flow facilities to provide a continuous bath of filtered clean air over the patients. This, plus the use of antibiotics, resulted in a remarkable control of infection during their recovery.

● During the past 5 years, abnormalities of the thyroid gland have been detected in some Marshallese people of Rongelap Island. The abnormalities, believed to be late effects of radioiodines deposited in the thyroid at the time (1954) they were accidently exposed to fallout, were detected in regular medical examinations. Treatment of the exposed people with thyroid hormone appears to be enhancing growth in children who have shown retardation of growth and has reduced somewhat the incidence of thyroid nodule formation.

● Clinical and laboratory data from human total-body irradiation exposures in the United States have been collected and encoded, and are being analyzed by computer. The values being obtained may be used to predict man's reaction to the radiations that might be encountered on space flights, and to further direct clinical explorations on the effect of radiation on both cancerous and normal processes.

Molecular and Cellular Level Studies

● The critical component of living cells—DNA—can be measured at the rate of 50,000 cells a minute with a new research tool. The new device employs two novel features: (*a*) A flow chamber using the laminar flow principle and (*b*) an intense beam of blue light from an argon gas laser. Each cell, as it crosses the narrow beam, emits a short burst of fluorescence in proportion to its DNA content. The method has great

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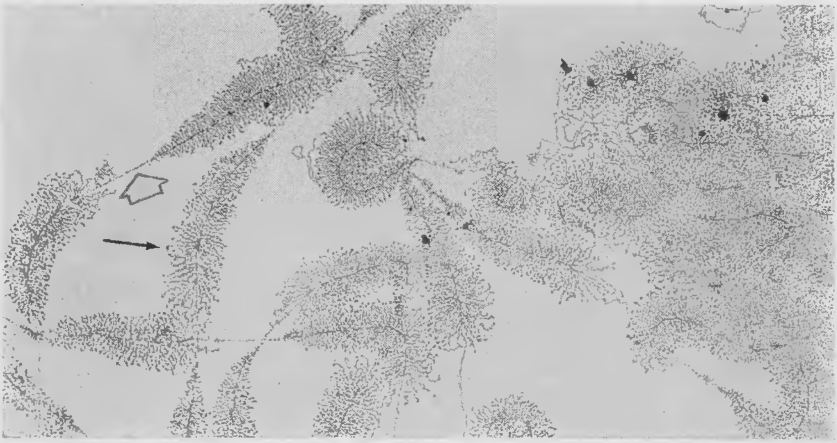
potential value, including applications to identification of cancer cells and to cell sorting.

● Control of levels of specific metabolites in the blood is of great importance in the treatment of many diseases, especially those caused by enzyme deficiency. It has now been possible to dialyse animal blood against a specific enzyme and change the level of an amino acid in the blood. Since many enzymes exist that modify or break down all the organic metabolites found in blood, it should be possible to control their levels in the blood precisely by suitable dialysis systems. This opens a way to use a whole series of highly specific agents in treating metabolic diseases.

● A new method to reveal molecular structure—photoelectron spectroscopy—is being used to study iron in the hemoglobin of blood cells and the iron and sulfur in proteins which function as electron carriers in plant photosynthesis.

Molecular Genetics

● The first visualization of genes of specific known function has been achieved. Direct visualization of genes provides a new and powerful



Electron Microscope Photos Have Shown for the First Time genes in the process of producing molecules of a human body chemical called RNA. It is RNA that "instructs" each cell in its designated work as a part of the whole organism. In this Oak Ridge National Laboratory photo, the genes, enlarged about 25,000 times actual size, are the spines of the carrot-shaped structures (example indicated by *black arrow*) which are linked together like beads strung along a necklace. Each gene (*white arrow* shows one) is producing about 100 molecules of RNA, which is seen as the hair-like fibers extending from the genes. The dark spots are photographic imperfections.

tool for exploring the immediate consequence of exposing the gene to radiation, chemical and physical agents for correlation with transcription and genetic regulatory ability.

Ultraviolet Radiation

- Studies have isolated enzymes believed to repair genetic material (DNA) damaged by ultraviolet radiation. The molecular basis of radiation repair will be better known when the properties of the enzymes are unraveled.

Environmental Sciences

- Attention is now focusing on the radiosensitivity of woody plants since they have been shown to be more radiosensitive than nonwoody species. A large number of deciduous woody plants possess a radiosensitivity range that is similar to that of mammals.
- Ecological studies indicate that the tropical rain forest is one of the most complex ecosystems in the world. In work in Puerto Rico, it has been shown that once all radioactivity is gone, a radiation-damaged rain forest recovers in a manner resembling a forest which has suffered other damage such as cutting. While the cycling of radioisotopes in the ecosystem is slow, with many species playing diverse roles in the forest, the cycling isotopes are used efficiently by the plants and trees and only a very small proportion is lost through runoff to rivers.
- Whether raising the mean temperature of a body of water has beneficial or harmful effects depends on the overall extremes of temperature with respect to all other factors affecting the ecological systems. Studies underway are leading to a better ability to predict and deal with the effects of temperature changes in large ponds, rivers, and estuaries.

NEW BIOMEDICAL RESEARCH FACILITIES

Some minor additions were made to existing facilities during the year and a second cyclotron was installed in an AEC medical center.

Medical Cyclotrons

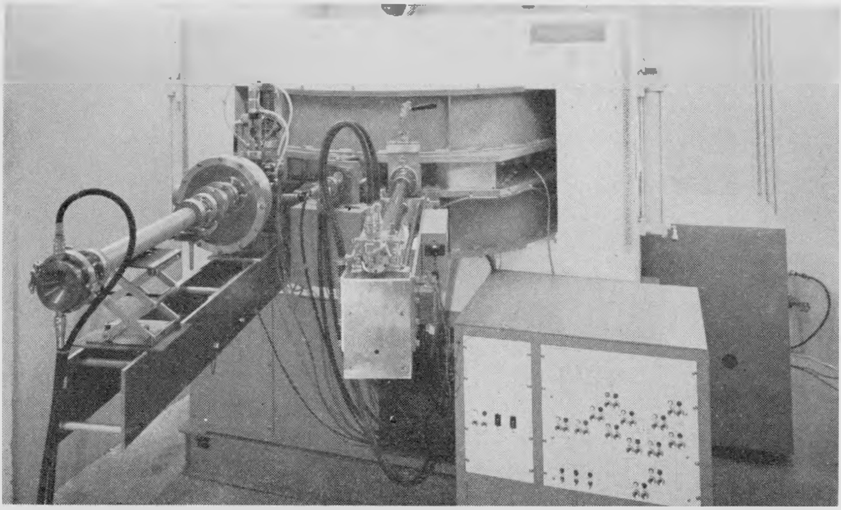
The rapid evolution of instrumentation and procedures used in nuclear medicine during the past several years has demonstrated a clear need in the AEC medical research program for an unlimited supply of very short-lived isotopes having half-lives of only seconds or minutes.

This need can be met by small helium-3 cyclotrons that can be used principally for making very short-lived, carrier-free [2] isotopes which are not otherwise available for experimental and diagnostic studies.

High specific activity materials that will be available from the cyclotron include the principal elements involved in the metabolic processes; namely oxygen, nitrogen, carbon, potassium, phosphorus, and iron and others with pharmaceutical uses that are not yet fully understood.

One such AEC-funded medical cyclotron is in operation, a second is in the preoperational testing stage, and a third will be installed during the summer of 1970. The first compact, helium-3 cyclotron was installed by the AEC in a medical center in June 1967. This cyclotron, now routinely used by the Sloan-Kettering Institute for Cancer Research (New York City) produces short-lived radioisotopes for medical use

[2] Usually in tracer experiments, radioactive atoms are added to a stable isotope, or normal element to obtain a quantity of radioactive mixture sufficient for handling, or to produce a radioactive mixture that will undergo the same chemical or biological reaction as the stable isotope. The advantage of carrier-free material is the lack of "contaminating" isotopes which reduce specific activity of the important radioisotope under study.



Compact Helium-3 Medical Cyclotron installed during 1969 at the Argonne Cancer Research Hospital (ACRH), Chicago, Ill., will be used for the unlimited production of short-lived (seconds or minutes) isotopes that are urgently needed in medical research. It will also be used for activation analysis using various particles: Fast and slow neutrons, protons, deuterons, helium and alpha particles for radiobiological studies. In the photo *above*, the external target facilities are seen at the left-hand side and the internal probe assembly for producing intense radioactive sources on the right-hand side. View is of the front of the cyclotron. The ACRH is operated for the AEC by the University of Chicago.

and fundamental metabolic research. A second helium-3 cyclotron has been completed at the Argonne Cancer Research Hospital (Chicago, Ill.) and is now in operation. Both of these machines are identical and produce 20-million electron volt (Mev.) helium-3 particles. A more powerful, 30-Mev. cyclotron is to be installed at the University of California at Los Angeles in mid-1970.

PHYSICAL RESEARCH

The AEC physical research program consists mainly of basic research investigations undertaken to discover new scientific knowledge and further the understanding of existing knowledge in physical sciences of high, medium, and low energy physics, mathematics and computers, chemistry, metallurgy and materials, and controlled thermonuclear reactions.

Approximately three-fourths of the AEC's overall basic physical research program is conducted at its national laboratories and other major research and development facilities. Research investigations also are conducted under contract. There are 578 contracts for such research at 145 institutions which includes universities and other educational institutions, a small number of nonprofit research institutions, commercial research organizations, and other Federal agencies.

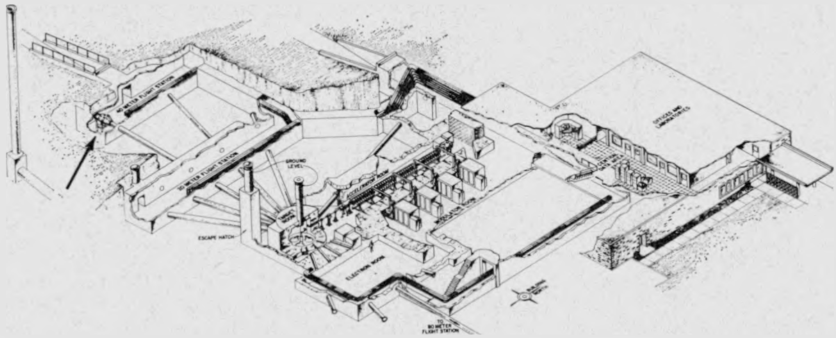
RECENT ADVANCEMENTS

The physical research section (Part 2) of the "Fundamental Nuclear Energy Research—1969" [3] report presents some of the noteworthy results of this research program. The following paragraphs highlight some of these achievements which are described in more detail in the supplemental report.

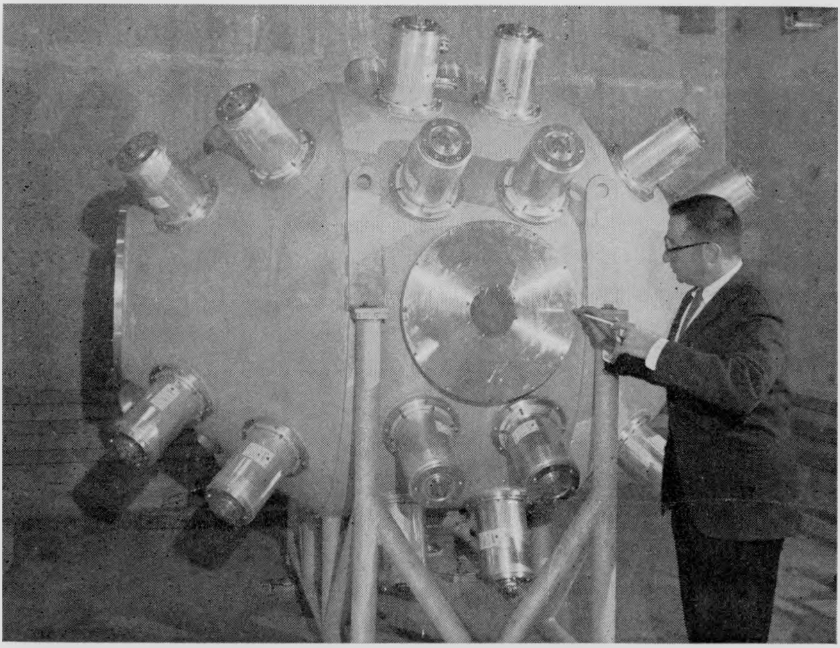
Low Energy Physics

- The availability of tritons in the 10 Mev. energy range has allowed a study to be made of a new theory of nuclear phenomena based on the effect of adding or subtracting pairs of particles.
- Stretched nuclei have been established as being part of the sequence of elongated shapes leading to fission and thus provide a valuable new vantage point for studying the complexities of nuclear fission.
- The energy change of an atomic X-ray from one isotope to another of a given element has been observed. This isotope shift is due to differences in the distribution of neutrons and protons in the nucleus from isotope to isotope.

[3] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3.75.



Operation of the New Oak Ridge Electron Linear Accelerator (ORELA) began in 1969. The 75-foot long accelerator located in the underground room near the center of the drawing *above,* will be used to fill gaps in existing measurements of neutron cross sections. Electrons from the accelerator strike a tantalum target centered in the target room, causing neutrons to be emitted in all directions (pipes radiating from target). Experiments with neutrons will be undertaken at the 20 meter (65 ft.) and 40 meter (130 ft.) flight stations. The photo *below* shows an 800-gallon scintillation chamber that will be installed at the end of a 40-meter flight tube. The equipment will be used primarily for studies in the liquid metal fast breeder reactor (LMFBR) program. The scintillation chamber, designed at Oak Ridge National Laboratory, is shown (*arrow*) installed in the outer tunnel (far *left*) of the ORELA layout (*above*). Continuing success in physical research is dependent upon the availability of such sophisticated scientific apparatus.



Medium Energy Physics

● Preliminary analysis of measurements have indicated a possible violation of time reversal invariance—a principle of symmetry in nature which requires that all physical laws be the same whether time flows in the forward direction or in the backward direction.

● The electron prototype accelerator (EPA), an experimental prototype for the Los Alamos Meson Physics Facility (LAMPF) now under construction, has proved out unique side-coupled cavity accelerator concepts and has been used to develop target and counting equipment for use with the 800 Mev. proton machine. A short version, one foot in length, is being produced commercially for hospital use as an economical, compact, high-energy, high-power, X-ray generator.

High Energy Physics

● Verification of the existence of three new Xi-star resonances, as well as the existence of a fourth resonance, has provided additional support for the SU(3) theory of elementary particles formerly known as the "eightfold way."

● New phenomena have emerged from charged pion photoproduction data. The unexpectedly abundant production of charged pions in the forward direction now requires modification of present theoretical thought and understanding in order to incorporate these new data into improved new models of pion photoproduction.

● Accurate measurements on how often the positive K-meson decays into each of its various decay modes have provided basic information vital to further exploration of this system which may lead to an understanding of weak interactions and the effect of the strong interactions on them.

Metallurgy and Materials Research

● Neutron beams from the High Flux Isotope Reactor have aided in completion of a study on the vibrational modes of aluminum impurities in copper crystals. This was the first observation of localized modes by coherent inelastic neutron scattering.

● It was found that radiation damage creates traps which decrease the rate of diffusion of rare gases in crystals.

● An important advancement in field ion microscopy was made with the imaging of gold. A method called hydrogen promotion was used successfully to obtain an image of a gold crystal.

● Metal-iron oxide-metal sandwiches have been developed which have low temperature electronic properties that make them potentially useful as switches, temperature sensors, amplifiers, and oscillators.

● An advanced theory has been developed which successfully explains the irreversible properties of superconductors and can also predict new properties of superconductors.

● The existence of a *Nernst* effect in thin films of pure soft superconductors lead, tin, and indium has been demonstrated for the first time.

● It is now possible to fabricate the synthetic radioactive element technetium into experimental devices and operate them at low temperatures required for superconductivity.

The Los Alamos Meson Physics Facility (LAMPF) is under massive construction in an effort to make it operational by July 1972. It is located atop the "little mesa" (Mesita de Los Alamos) near the Los Alamos Scientific Laboratory in New Mexico. The meson "factory," as it is sometimes called, will be a basic research tool that will be useful in life and physical science study applications. Its heart will be a linear accelerator more than a half-mile in length.

● The application of high external pressures has been found to accelerate annealing of radiation damage in molybdenum.

Chemistry Research

● With 103 chemical elements already confirmed, the next to be added to the periodic table would be the first transactinide element, element 104. Following the bombardment of californium targets at Lawrence Radiation Laboratory, Berkeley, with carbon ions and curium targets with oxygen ions, three isotopes of element 104 were positively identified and there is tentative evidence for a fourth isotope.

● Through use of an ingenious isotope identifier "telescope," four new isotopes—lithium-11, boron-14, boron-15, and carbon-17—have been discovered. These isotopes were found among the many products obtained by shattering a uranium nucleus by collision with 5.5 Bev. protons.

● The manmade heavy-element radionuclide, califorinum-252, is a neutron source potentially useful for nondestructive analyses in geological field or space explorations providing a versatility and portability not readily available in other neutron sources.

● An alloy of iron and titanium has been discovered this past year which will absorb (and release) substantial quantities of hydrogen gas near room temperature and at pressures of one atmosphere. Use is foreseen with fuel cells, combustion engines, and, possibly, with hydride-based heat engines.

Controlled Thermonuclear Research

● The plasma produced in the 2X Facility is of a density and temperature approaching that which would be required in a fusion reactor. Compared to the first experiment in this facility, the confinement time of the hot plasma has been increased more than 40 times.

● The confinement time in the toroidal direct current octupole device is 300 times the *Bohm* value. This device has eliminated plasma instabilities and the confinement time is the same as that required for a fusion reactor. However, the plasma is of low density and low temperature.

Mathematics and Computer Research

● A rapid computer-controlled scanner has been developed to automatically count the tracks of charged nuclear particles on emulsion plates exposed in a magnetic spectograph.

PHYSICAL RESEARCH FACILITIES

To a great extent, success in basic physical research is dependent upon the availability of advanced research facilities and the accompanying unique and sophisticated scientific apparatus.

Powerful Electron Microscope

The most powerful campus-based electron microscope in the Nation was dedicated at Berkeley, Calif., in June 1969, as part of the inorganic materials research facilities of the Lawrence Radiation Laboratory. The microscope, costing $250,000, can operate at a peak voltage of 650 kilovolts (kv.) as opposed to 100 kv. for conventional instruments. In basic materials research, the lower voltage instruments used in transmission microscopy require that samples be prepared in extremely thin form—so thin that it becomes questionable whether the effects observed are truly representative of the body of the material or effects strongly influenced by the surface. The higher voltage microscope permits the study of: (*a*) Thicker samples, thereby reducing the importance of this question; (*b*) samples difficult to prepare in thin form, *e.g.*, ceramics; (*c*) samples of heavier metals, *e.g.*, uranium and tungsten; and (*d*) interfaces; *e.g.*, films on substrates. The resolution of the new instrument is better than 10 angstroms by the crystal lattice test. The new microscope will also be used for biological and reactor materials research.

Solid State Science Building

Argonne National Laboratory's new solid state science building was dedicated in May 1969. Built at a cost of $4 million, the building has 38 experimental laboratories for solid state physics and materials research as well as offices, conference rooms, and supporting facilities, within its 109,500 square feet.

Four of the 38 laboratories are designed for the handling of radioactive materials. Facilities are provided for research at extremely low temperatures and at moderately high magnetic fields. An irradiation facility containing a 20,000-curie radiocobalt gamma ray source is also housed in the building. Specialized shops are available for the construction of experimental instruments, electronic circuits, optical apparatus, and for the preparation of research materials. Plans include the installation of an ultra-clean room to be used for growing high purity crystals.

In addition to housing Argonne's solid state science program, the new building will provide opportunities for collaborative research and the use of specialized equipment to scientists from other research centers and universities.

Los Alamos Meson Physics Facility

Construction of the Los Alamos Meson Physics Facility (LAMPF), the most powerful meson producing accelerator in the world, is proceeding at the Los Alamos Scientific Laboratory. Accelerator use will revolve, primarily, around the high intensity primary and secondary beams which are needed to extend the knowledge of nuclear structure and nuclear forces into regions not now accessible and to bridge the gap between nuclear and subnuclear physics. At the end of the year, 70 percent of the facility design was complete and 30 percent of the overall construction had been completed.

Controlled Thermonuclear Research

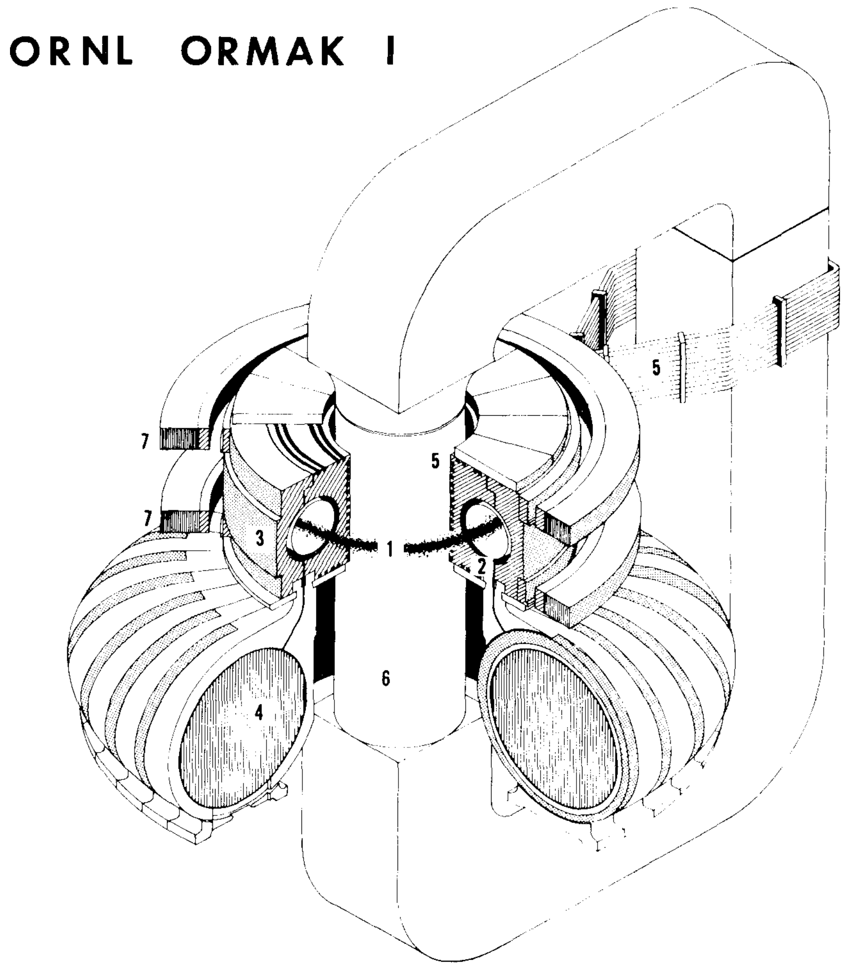
At the time of congressional hearings on the AEC's budget (April 17, 1969) the U.S. had received reports concerning recent Soviet advances in experiments carried out in their "tokamak" [4] facilities. Later that same month, a select panel of U.S. scientists discussed and evaluated the Soviet developments concluding that the Soviet results, if valid, are impressive and represent the best combination of density, temperature, and confinement time achieved in controlled thermonuclear research anywhere in the world. Despite some uncertainties about the validity of the Soviet plasma temperature measurements, the panel recommended that it was imperative that the U.S. become immediately involved in tokamak research, both to assess the merits and to be in a position to follow up a successful confirmation of the Soviet claims. Subsequently, five fusion research laboratories submitted proposals to the AEC for research in the tokamak field. The AEC approved the fabrication of a tokamak system at Oak Ridge National Laboratory and the conversion of the Model-C Stellarator to a tokamak at the Princeton (N.J.) Plasma Physics Laboratory.

Oak Ridge Electron Linear Accelerator

Initial operation of the Oak Ridge Electron Linear Accelerator (ORELA), during 1969, provided a facility for neutron cross section

[4] *Tokamak*—The name given to a class of controlled fusion devices in the U.S.S.R.

measurements that will fill in a gap existing between low-energy measurements made at the Rensselaer Polytechnic Institute (Troy, N.Y.) linear accelerator and high-energy measurements made at the



The New ORMAK Fusion Research Device is being fabricated at Oak Ridge National Laboratory, and is based on controlled thermonuclear experimental devices of the Soviet "tokamak" class which have shown improved temperatures, plasma densities, and confinement characteristics. It is designed to be a highly symmetrical machine: with a tokamak plasma (*1*) confined in a high vacuum linear ring accessible to diagnostic instruments at (*2*) and surrounded by a magnetic field coil (*3*). A toroidal transformer (*4*), below the plasma chamber, couples the generators to the upper torus. Plasma current driving windings may be seen at two places (*5*) and the induction core (*6*) provides a plasma current near 100,000 amperes. Torus holding bands are at (*7*). The device is expected to be completed in mid-1970.

Argonne and Oak Ridge Van de Graaff accelerators. ORELA was designed both to produce an intense pulsed neutron source and to accommodate a number of experiments simultaneously. Tubes, called neutron flight paths, radiate from a heavily shielded circular room housing the neutron source—a tantalum target which emits neutrons in all directions when bombarded by electrons. Bursts of electrons from an electron "gun" are boosted in energy as they travel the 75-ft.-long accelerator and then are injected into the target. Bursts as short as 2.3 nanoseconds,[5] and at rates as great as 1,000 bursts per second are attainable. With a peak beam current of 15 amperes and an average electron energy of 140 Mev. (million electron volts), neutrons are produced at peak rates of four billion billion a second (10^{18}). This high production rate—10 times the peak neutron intensity available at other electron accelerators devoted to neutron cross section measurements—provide more precise data.

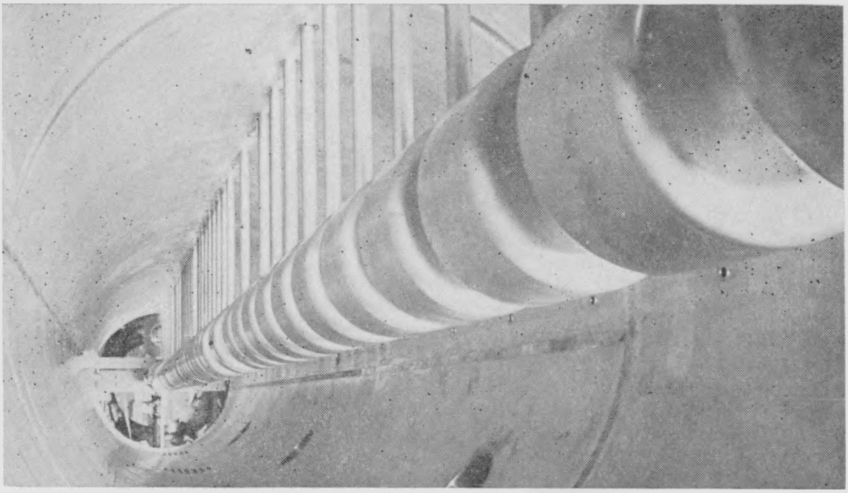
The massive data output of ORELA required the development of sophisticated data-handling techniques. The system utilizes three linked-computers in the ORELA building connected by telephone lines to three linked-computers at other locations. Signals from any one experiment can be timed to within several nanoseconds, and the signals selected from the processing can be digitized and stored within microseconds.[6] Within minutes following the accumulation of a set of data, the interim results can be plotted as graphs so that the course of the experiment can be evaluated and adjustments made if necessary. Finally, the data from the experiment can be stored for later use and further analysis. The data-handling equipment available for some of the experiments can process as many as 7,000 nuclear particle events per second.

National Accelerator Laboratory

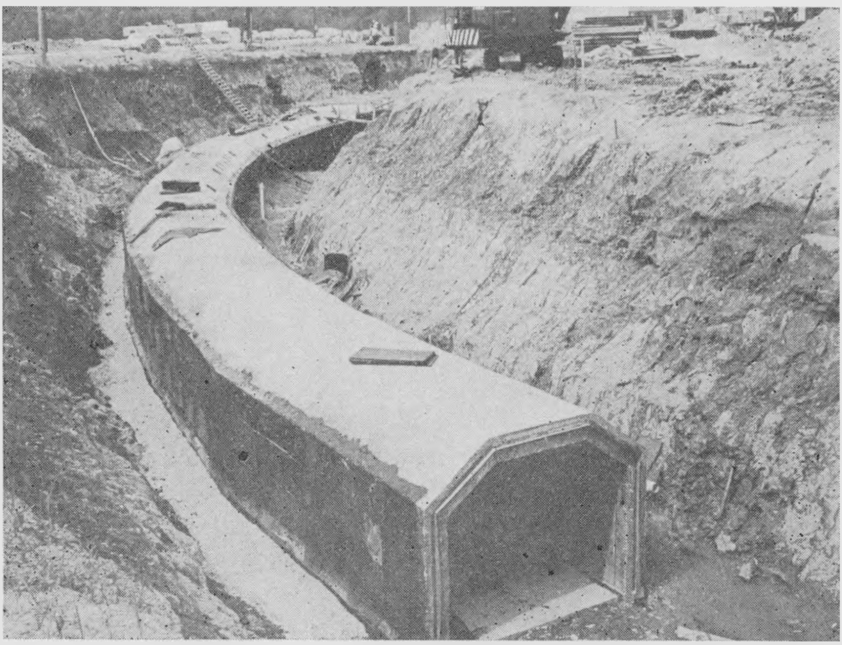
Construction of the National Accelerator Laboratory (NAL) was fully authorized by Congress for a total of $250 million, and funds in the amount of $91.1 million have been appropriated for work through mid-1970.

On April 10, 1969, the State of Illinois turned over the 6,800-acre site to the AEC. On April 29, the AEC announced that the laboratory will be named in honor of the late Dr. Enrico Fermi. Formal dedication and naming of the Enrico Fermi Laboratory will not take place until major construction work has been completed and the facility is in operation, probably in fall of 1972. Engineering design by the NAL

[5] One nanosecond = one-billionth of a second.
[6] One microsecond = one-millionth of a second.



The 200-Bev. Accelerator is undergoing construction near Batavia, Ill. The photo *above* shows the interior of the prototype 10-Mev. linear accelerator cavity built and operated at the National Accelerator Laboratory with which beam tests are being conducted. The construction photo *below* shows work on the tunnel for the booster accelerator, one of three major accelerators in series that will make up the 200-Bev. facility. The booster accelerator takes protons accelerated to an energy of 200 Mev. from the linear accelerator and further accelerates them to 10 Bev. for injection into the main accelerator ring. The booster will be a rapid cycling synchrotron about 500 feet in diameter.



staff and DUSAF [7] is proceeding on schedule and is over one-third complete. The major facilities now under construction, and about 7 percent complete, include the LINAC enclosure, booster accelerator enclosure, cross gallery, one-sixth of the main ring structure, two industrial buildings, roads, central utility plants and some utilities.

[7] DUSAF is a joint venture firm composed of the following: Daniel Mann, Johnson, and Mendenhall, Los Angeles; the Office of Max O. Urbahn, New York; Seelye, Stevenson, Value and Knecht, Inc., New York; and George A. Fuller Co., New York.

Chapter 16 | INDUSTRIAL PARTICIPATION ASPECTS

NUCLEAR INDUSTRY GROWTH

Despite the limited number of new orders for nuclear powerplants in 1969, the nuclear industry as a whole is experiencing a period of sustained growth sparked in large part by the surge of orders for nuclear powerplants in the 1966–1968 period.[1] In addition, industry spokesmen express undiminished optimism as to the industry's future. Among the many factors supporting this view:

- Shipments of a selected group of nuclear products as reported by the U.S. Bureau of the Census were at more than half a billion dollars—up by more than 40 percent in 1968 [2] from the 1967 level.
- Net orders received for a limited group of nuclear products as reported by the Bureau of the Census, although below the 1967 level of $1.6 billion, were in excess of $1.0 billion in 1968.[2]
- At the end of 1969, there were 97 nuclear powerplants operable, under construction, or on order with a total estimated cost of $12 billion.
- Safe and reliable operation of nuclear central station powerplants continued to be demonstrated as a dozen U.S. plants approached a total generation of 60 billion kilowatt hours.
- Nuclear powerplants continued to show a potential to be economically competitive with fossil-fired plants over much of the United States.
- There is a continuing urgent need to make the most effective use of all U.S. energy resources to meet the rapidly expanding demands for electricity.

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[1] For a complete report on the atomic energy industry, see "The Nuclear Industry—1969," prepared by the AEC's Division of Industrial Participation and available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.50.

[2] Latest available figures; Bureau of Census figures for 1969 will not be available until about mid-1970.

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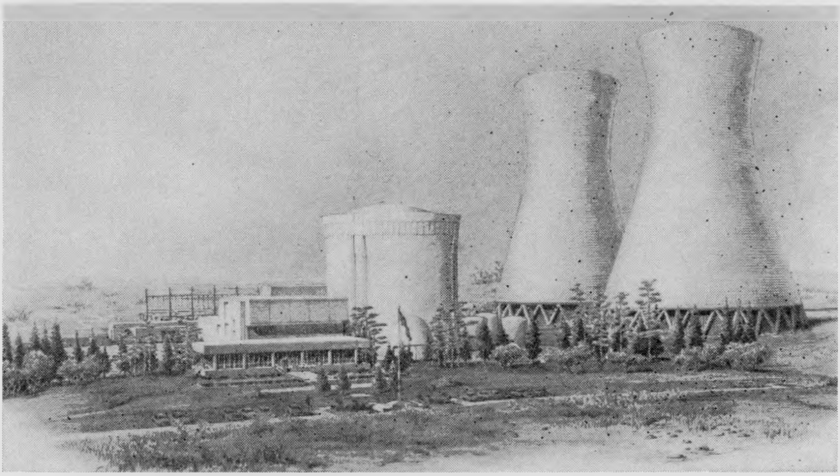
COOPERATION WITH INDUSTRY

Since the inception of the U.S. atomic energy program, the Government and private industry have worked in close cooperation in advancing both the military and civilian uses of nuclear energy. In order to take full advantage of the industrial skill, experience, and initiative, the AEC's first plants and laboratories were constructed and operated by independent industrial and educational organizations.

In writing the original Atomic Energy Act of 1946 and in its extensive revision in 1954, the Congress recognized the importance of this Government-industry partnership by establishing as policy that the development and use of atomic energy be directed so as to "strengthen free competition in private enterprise." The efforts of both the AEC and the Congressional Joint Committee on Atomic Energy to encourage broad participation by industry have contributed much to



Two Huge Parabolic Water Cooling towers, standing taller than a 17-story building, will mark the site of the Sacramento Municipal Utility District's (SMUD) $200 million Rancho Seco nuclear electricity generating station when the plant—shown in the artist's conception—begins operation in mid-1973 near Ione, Calif. A familiar sight in Great Britain, the two 425-foot high cooling towers will be the first of their type used in the United States for a nuclear powerplant. They will condense the steam—after it has turned the electricity-producing turbines—for recirculation through the system. The Babcock & Wilcox Co.-built 800 Mwe. pressurized water reactor will be housed in the 185-foot high circular building in the center. Construction of the plant began during 1969. When completed, SMUD has long-range plans to make about half of the 2,400-acre site into a recreational area. A small reservoir now on the site will be enlarged into a 160-acre lake which will hold standby cooling water for the Rancho Seco plant.

this country's position of world leadership in the development and use of nuclear energy.

As a part of its continuing program of cooperation with the private nuclear industry, the AEC has found it essential to maintain continued communications with industrial associations and with State and local governments.

Industry Associations

Frequent informal meetings between the AEC and leaders of several industrial associations with diverse interests in the nuclear field have provided for a free and informative exchange of views on matters of mutual interest and concern. In 1969, the Commissioners met on this basis with the Board of Directors of the Atomic Industrial Forum, and with the president and managing director of the Edison Electric Institute.

Other associations also provide important channels of communication between AEC and industry. These include the Chamber of Commerce of the United States, the American Public Power Association, the Association of Nuclear Instrument Manufacturers, the National Security Industrial Association, and the Manufacturing Chemists Association. Individual Commissioners and members of the AEC staff met during 1969 with representatives of these groups.

COMPETITION IN THE NUCLEAR INDUSTRY

As industrial participation in nuclear activities has expanded, the AEC has been increasingly concerned with means of assuring full and free competition in the sale of nuclear services and supplies. For example, one of the early situations (in 1964 and 1965) was that there were only two suppliers of commercial nuclear power reactors. This led to discussions with the U.S. Department of Justice and to agreement on a jointly sponsored study of the nuclear power supply industry which was subsequently carried out by Arthur D. Little, Inc. (Cambridge, Mass.). This study provided background information and economic data on each segment of the industry and analyzed its economic aspects. The resulting report, which included a discussion of policy objectives and possible approaches, was published in its entirety early in 1969.[3]

Discussions of competition in the emerging nuclear industry have continued between the AEC and the Department of Justice, and the

[3] *Competition in the Nuclear Power Supply Industry,* a report by Arthur D. Little, Inc., to the AEC and the U.S. Department of Justice, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $4.50.

In 1971. Some 841 Megawatts of Electricity will flow from the first in a trio of similar pressurized water reactors (*center left* of sketch) which together will comprise the largest nuclear power project yet undertaken by a private utility in the United States. The Duke Power Co.'s Oconee Nuclear Station, north of Clemson, S.C., will provide a significant block of energy for the southeastern United States. When all three reactors are operating in 1973, the 2,613-Mwe. output will make up a quarter of the company's total generating capacity. As shown in this Bechtel Corp. sketch, the Oconee Nuclear Station is part of the Keowee-Toxaway Project, a massive regional development plan in the Piedmont Carolinas which will create 26,000 acres of lakes and nearly 400 miles of shoreline by damming the Keowee and Little Rivers. The dams provide for two 70-Mw. hydroelectric generators and four 152.5-Mw. reversible pump-turbines to bring the total generation capability of the project to more than 3,400 Mwe. Each of Oconee's three Babcock & Wilcox pressurized water reactors will be housed in separate containment buildings, but the first two units will share fuel handling and storage facilities. A nine-story auxiliary building will house a control room for Units 1 and 2, in addition to pumps, heat exchangers, tanks, switchgear, instrumentation, laboratory, and facilities for operating personnel. Unit 1 will have an 841-Mwe. output while Units 2 and 3 will be rated at 886 Mwe. Duke is developing the lakes and shoreline into recreation areas with campsites, hunting, fishing, picnicking, and water sports. A visitors center, which opened in mid-1969, is shown between the lake and the reactor buildings. It provides the public with clear views of the nearby dams and construction at the nuclear station. Animated displays tell the story of atomic energy and explain plant operation. (See also Chapter 6 illustration.)

latter has been kept informed of developments in the industry since the Arthur D. Little report was prepared. In general, the nuclear field may now be characterized as highly competitive. There are now four suppliers of commercial nuclear power reactors, with two more firms developing a potential for additional competition. There is also substantial competition in the production and processing of nuclear reactor fuel and in the commercial applications of radioisotopes and ionizing radiation.

The importance of effective competition to a healthy industry, and the need to carry out AEC activities in a manner consistent with the antitrust laws as administered by the Department of Justice, make this an area of continuing scrutiny. Vertical integration (ownership or control of all phases of an industrial process from raw materials to product) within the industry and the emergence of petroleum-industry interest in both coal and nuclear energy were particularly noteworthy in 1969.

REGIONAL SUPPORT ACTIVITIES

The support of nuclear activities on a regional basis frequently offers a means of accomplishing objectives where support by an individual State could be beyond its means—both technically and economically. Interstate compacts provide a means of coordinating these regional efforts.

Southern Interstate Nuclear Board

Two atomic energy development projects were conducted, under AEC contract, by the Southern Interstate Nuclear Board (SINB) during 1969. A "Program Design and Systems Analysis" for the Isotopes Information Center at Oak Ridge National Laboratory was carried out to foster better utilization of isotopes information by business and industry. The second project, "Uranium Occurrences in the South," is aimed at a systematic compilation of information on known and potential uranium mineral resources in the region. The SINB also initiated special projects on: (*a*) Regional science policy and planning; (*b*) highway transportation of radioactive materials; (*c*) State and regional policy studies on nuclear power; (*d*) nuclear manpower resources; and (*e*) radioactive waste disposal.

Created in 1961 upon ratification of an interstate compact, the Southern Interstate Nuclear Board provides a variety of advisory and developmental services to its 17 member States [4] in fostering the sound development of atomic energy, space technology, and related sciences in the South; in helping the States to meet the growing influence of nuclear energy in new fields as well as in traditional areas of State responsibility; and in encouraging a proper balance of authority and responsibility between the States and the Federal establishment.

The SINB serves as an important communications link between Federal agencies and regional leaders. Federal cooperation with the board was authorized by Public Law 87–563, enacted by the U.S. Congress in 1962. The Act also provides for a Federal representative to the SINB,[5] appointed by the President of the United States and reporting to him through the Chairman of the AEC.

Western Interstate Nuclear Board

A Western Interstate Nuclear Compact (WINC) was endorsed by the Western Governors [6] at their annual conference in 1967 and since then, 11 western States have passed legislation authorizing the compact. Representatives of these States met in Seattle, Wash., in September 1969 to establish a Western Interstate Nuclear Board and provide an administrative framework within which the board will operate. High on the board's agenda are discussions to identify nuclear-related projects which WINC members will mutually pursue. The need has also been stressed for close cooperation between the States in bringing the use of the peaceful atom into prudent focus by preparing and issuing information that is both factual and understandable by the public.

Congressional legislation has been introduced to grant the consent and approval of Congress to the compact and to provide for Federal cooperation with the board. In supporting this legislation, the AEC expressed the view that the common interest of the several States in achieving maximum benefit from the exploitation of peaceful uses of atomic energy could be usefully and effectively served by coordination on a regional level.

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[4] Composed of member States of the Southern Governors' Conference: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Affiliate membership has been offered to Puerto Rico and the Virgin Islands. SINB headquarters are at 800 Peachtree St., N.E., Atlanta, Ga. 30308.

[5] On Apr. 30, 1969, President Nixon appointed Sterling Cole of Arlington, Va., as the Federal representative to the board. A former Congressman, Mr. Cole served on the Joint Committee on Atomic Energy (JCAE) from 1947 to 1957 and was JCAE Chairman in 1953–54. He resigned from Congress in 1957 to serve as the first Director General of the International Atomic Energy Agency (IAEA).

[6] Representing: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. All, except Hawaii and Montana, had approved the compact at year's end.

Chapter 17

ADMINISTRATIVE AND MANAGEMENT MATTERS

EMPLOYMENT

Greater participation by private industry in expanding the peaceful uses of atomic energy is reflected in a recent study of employment trends in the atomic energy field, 1963–68.[1] The study was compiled by the Bureau of Labor Statistics from annual surveys designed to collect information on the levels and distribution of employment in 16 segments of atomic energy activities.

The report showed that:

- About 144,400 persons were employed in May 1968 in atomic energy work throughout the 16 industrial segments, a 4-percent increase over the 1963 level of 138,500. Employment at Government-owned facilities remained relatively stable at about 101,000 during the 1963–68 period, while employment in investor-owned facilities rose substantially—from 37,200 to 43,400—a 17-percent increase.
- Scientists, engineers, and technicians made up 43 percent of the total atomic energy employment in 1968, as compared to 38 percent in 1963. The number of scientists and engineers engaged in research and development work increased 19 percent during the period.
- Funds provided by the Federal Government supported 78 percent of the employment of all scientists and engineers in atomic energy work in 1968.

Labor Management Relations

The Atomic Energy Labor-Management Relations Panel intervened in only one labor-management dispute at Government-owned contractor-operated facilities during 1969. It involved a contract renewal

[1] "Occupational Employment in Atomic Energy Fields—1963–1968" will be available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

dispute between Goodyear Atomic Corp. (Portsmouth, Ohio, Gaseous Diffusion Plant) and the Oil, Chemical, and Atomic Workers Union. Settlement was reached on the basis of panel recommendations.

Work Stoppage Record

Time lost because of strikes by AEC contractor employees at Government-owned installations during 1969 amounted to 0.5 percent of the estimated scheduled working time. A total of 143,073 man-days was lost during the year, of which 12,344 (0.5%) occurred on construction projects, and 130,729 (0.5%) occurred in production, research and development, test activities, and services.

Strikes and days lost from strikes during the past 5 years, excluding those in construction, were:

Year	Number of strikes	Man-days lost	Percent of scheduled time lost
1965	11	98, 254	0. 03
1966	13	178, 258	. 66
1967	4	21, 173	. 08
1968	3	620	. 002
1969	14	130, 729	. 50

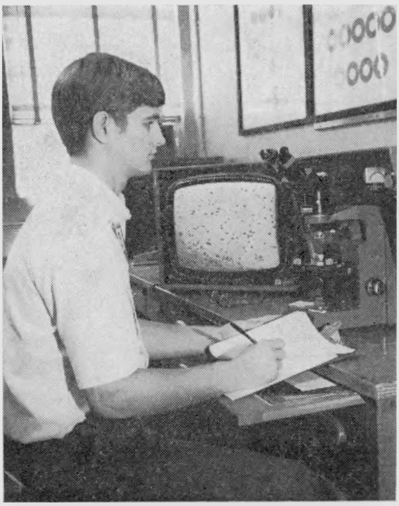
AEC EQUAL EMPLOYMENT OPPORTUNITY

Early in the year, the position of Assistant for Equal Employment Opportunity Programs was established in the Office of the General Manager to provide liaison with national and local organizations for furthering the AEC's efforts in equal employment opportunity (EEO), to improve minority participation in all AEC programs, and to provide advice and guidance for agency officials. Major attention is being devoted to the improvement of affirmative action programs of equal employment opportunity in AEC Federal employment and in Government-owned, AEC contractor-operated industrial and laboratory facilities. Throughout the AEC organization, primary emphasis is being placed upon affirmative action to assure equality of employment opportunity. Counselors have been trained to assist informal resolution of complaints by employees who believe there has been discrimination on the basis of race, color, religion, sex, or national origin and special emphasis has been placed on increasing opportunity for minorities in supervisory and upper grades. An educational program has been developed to provide sensitivity and understanding of minority disadvantages and problems, and the structure of racial prejudice;

it includes films dealing with equal employment opportunity, background and history of minority groups, and their role in the development of our country. Training and development plans for minority group employees are under constant analysis to assure that all training opportunities are being considered.

As a part of the AEC coordinated recruitment program, short- and long-range recruitment needs are being identified, job requirements are

Summer Work Was Provided for 1,252 young men and women as the AEC and its contractors cooperated in the annual Youth Opportunity Campaign (YOC) in 1969. Shown in the photo (*above*) are some of the 66 students who worked at Pacific Northwest Laboratory, near Richland, Wash., during a session in which the purpose of the program was explained. At *left*, a YOC Summer employee records metallographic data from a Quantimet image analyzing computer at AEC's Feed Materials Production Center, Cincinnati, Ohio. The National Lead Company of Ohio, contract operator of the plant, employed 16 young men and women in the summer YOC program.



being developed, and made known to sources that can assist in locating minority candidates. College and university enrollment statistics on minority students and graduates are used to pinpoint potential sources for recruitment in needed occupational areas. Contacts have been extended with local minority group organizations, colleges and schools.

Under the 1969 summer employment program, 180 youths were employed by the AEC. Of these, 80 percent were from minority groups.

Equal Employment and Training

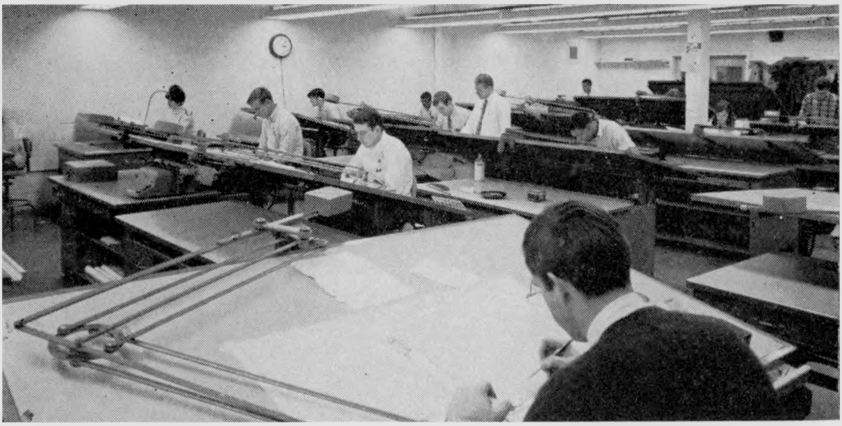
Youth Opportunity Campaign

During the summer of 1969, contractors at AEC facilities employed 1,252 needy youths under the Youth Opportunity Campaign (YOC), an increase of 236, or 23 percent over 1968; 67 percent of these young people were members of minority groups. A 2-year statistical summary of the YOC employees shows:

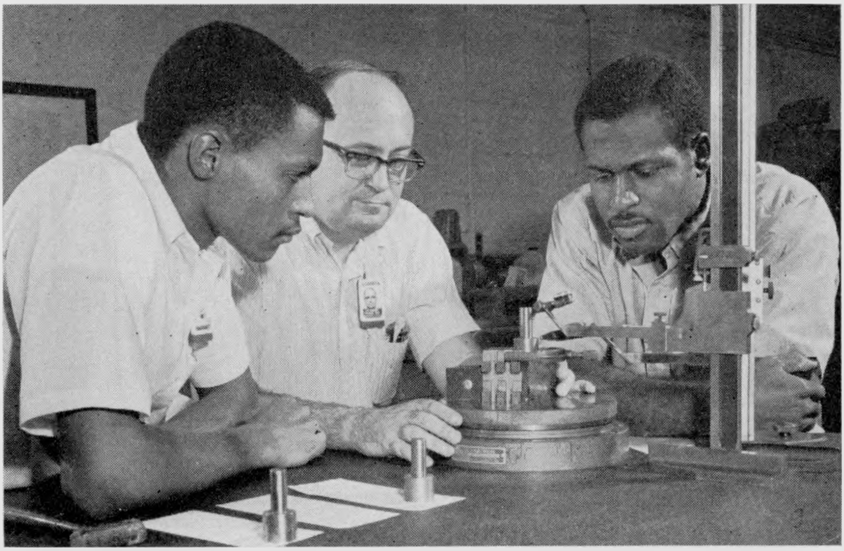
	1969	1968
Total participants	1,252	1,016
Negro	552	456
Other minority	288	200
Sex:		
Male	788	646
Female	464	370
Ages:		
16–18	666	545
19 and over	586	471
School status:		
High school dropouts	13	24
High school students	229	137
High school graduates	429	486
College students	581	369

Minority Employment

Contractors at AEC-owned facilities continued their efforts to expand employment opportunities for minority personnel. During the 12 months ending September 1969, these contractors hired 14,802 persons including 1,845 Negroes and 1,462 other minorities. As of October 1, Negroes represented 4.7 percent and other minorities 5.0 percent of total employment. One year earlier, these rates were 4.1 percent and 4.2 percent respectively.



Training and Technology Project Students at the Oak Ridge Y–12 Plant are shown *above* performing assignments in the drafting class. The project, administered by Oak Ridge Associated Universities, trains persons in technical skills required by contemporary industry. In the photo *below*, training and technology project students check the quality of a machined item in the school's dimensional inspection laboratory. The industrial training is supported by the U.S. Department of Labor and the AEC in cooperation with the U.S. Office of Education. The program is administered locally by the Oak Ridge Associated Universities and the Y–12 Plant.



Experimental Training

The training and technology (TAT) project at Oak Ridge, Tenn., has continued to demonstrate that the talents and resources of modern, advanced industry, in combination with those of educational institutions and governmental agencies, can add a significant new dimension to the nation's efforts to train persons for critically needed job skills in technology-based industry.

The project[2] has been conducted since September 1966, at the AEC's Y–12 Plant—an industrial complex devoted to the most advanced chemical and metallurgical technology.

Training consisted of skill development and technical theory in six occupational areas, trade-related instruction in mathematics, physical science, and communications, and special emphasis on development of career and employment concepts. Training and related services were provided jointly by experienced staff members of the Nuclear Division of Union Carbide Corp., the University of Tennessee, and Oak Ridge Associated Universities. Occupational areas in which training has been conducted are mechanical drafting, machining, physical testing technology, industrial electronics, combination welding, and laboratory glass fabrication; the latter has been replaced by general mechanics training.

Nearly 1,000 persons, a large majority of whom were unemployed or underemployed, have completed training during the 3-year period. Among the significant findings of the TAT experience are:

(1) Training imparted by industrial employees and emphasizing industrial standards can, when combined with modern educational techniques, result in the development of a high level of skill and technical knowledge in less than 1 year.

(2) Persons trained in this industrial atmosphere develop an understanding of such necessary concepts of industrial employment as employer-employee relationships, supervisor-workers relationships, and the discipline of punctuality and regular attendance.

(3) Methods used appear applicable to many of the nation's manpower training efforts for disadvantaged and minority persons.

(4) These methods are especially applicable to Government contractors and agencies, providing trained employees for production purposes, while also contributing to manpower development objectives in the national interest.

(5) A multiplicity of organizations with highly divergent interests and responsibilities can cooperate effectively under the leadership of strong management in a comprehensive program that pro-

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[2] See p. 270, "Annual Report to Congress for 1968."

vides for all aspects of the employment process from recruitment through selection, training, placement, and follow-up. In addition to the organizations conducting the TAT training, active participation was provided at a number of levels by the Tennessee Department of Employment Security, the Tennessee Division of Vocational-Technical Education, the Oak Ridge Adult Education Program, and units of organized labor.

National Survey of Compensation

A survey [3] providing information essential to the Government for evaluation of 1968 salary levels paid scientists and engineers by cost-

[3] The "National Survey of Compensation Paid Scientists and Engineers Engaged in Research and Development, 1968," for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $2.50.

A group of 23 Young Men, selected by the AEC's National Accelerator Laboratory (NAL) began a course of technical training in February at Oak Ridge, Tenn. The industrial skill training was conducted by the Training and Technology (TAT) Project at the Oak Ridge Y–12 Plant. The participants, all between the ages of 18 and 31 and nearly all from the inner city of Chicago, were the first participants in a program to train unemployed or underemployed minority group members to fill specific skilled jobs at the AEC's high-energy physics research center now under construction near Batavia, Ill., 30 miles west of Chicago. The group of participants is shown just prior to their departure for Oak Ridge from Chicago. The men were trained for these jobs through the TAT project, which is supported through an interagency agreement between the AEC and the Department of Labor under the Manpower Development and Training Act. Graduates of this program are now employed in NAL laboratories and design sections.

reimbursed contractors has been completed by Battelle Memorial Institutes, Columbus (Ohio) Laboratories. The survey was made under a contract jointly funded by the Department of Defense, National Aeronautics and Space Administration, and the AEC. A contract has been signed with Battelle for a similar 1969 survey, funded entirely by the AEC. Consistent with interagency understandings reached at the time the new survey was approved, this national survey replaces a survey previously conducted by Los Alamos Scientific Laboratory.

The Battelle study consolidates and presents data by four levels of supervision and by three levels of degree. The data reveal that significant differences in pay occur among the four levels and that salaries at each level of supervision are related to the degree level held by the incumbents. It is anticipated that this type of information, along with data on field of degree, occupation, and type of establishments, will lead to a better understanding of the various factors affecting salary levels paid scientists and engineers.

DIVERSIFICATION AND TRANSFER

AEC-contractor private diversification activities[4] continued, during 1969, to strengthen the economic base of the Richland, Wash., area. A third phase of construction to a major laboratory facility was started as was a meat packing plant. Construction of a resort and convention center started in 1968 was completed during the year.

The termination of ownership and management of community facilties at Los Alamos, N. Mex., was essentially completed on July 15, 1969, with the final sale of properties classified for sale.

New Diversification Activities

Battelle-Northwest, the Battelle Memorial Institute subdivision which operates the AEC's Pacific Northwest Laboratory, awarded a contract on August 4, 1969, to construct a 16,000-square-foot Engineering Development Laboratory addition to its private Richland research complex. This $700,000 high-bay fuel fabrication laboratory, the third phase in Battelle's planned construction program, will be used initially for nuclear power reactor fuel development research. Jersey

[4] The diversification policies adopted by the AEC were established to assist the economy of the Richland, Wash., area following the AEC cutback in production announced by the president on Jan. 8, 1964. The contractors now operating the AEC's varied Hanford plant facilities (prior to 1964, all facilities were under a single contractor) have established commercial activities with total employment substantially compensating for reduction a site employment as a result of continuing facility shutdowns.

Nuclear Co., a division of Standard Oil of New Jersey, announced in mid-year its plans to locate nuclear fuel fabrication facilities in the Richland area as an outgrowth of the research and development work being done by Battelle-Northwest.

Hanford House, a hotel-convention-resort facility at Richland constructed by Atlantic Richfield Hanford Co. (ARHCO) was completed on August 24, 1969. ARHCO is the AEC contractor operating the chemical processing facilities at the Hanford Works, and the hotel is one of its diversification activities. Also located in the Richland area is a meat packing plant capable of processing 135,000 cattle a year which is being built by ARHCO for operation by the Cudahy Co. of Phoenix, Ariz. Construction of the over $5 million meat packing plant started on October 28, 1969.

Precious Metal Recovery From Atomic Wastes

Ten firms responded to the AEC's advertised request of October 1968 for expressions of interest from industry in the commercial recovery and use of fission-product rhodium, palladium, and technetium from Hanford high-level radioactive wastes. The recovery of the precious metals would be accomplished coincident to AEC's scheduled processing of the wastes for long-term storage, and would involve construction of private facilities at Hanford to recover the metals, and thereby benefit the local economy. The firms indicating a formal interest in the recovery of the metals were Engelhard Industries, Atlantic Richfield Co., Matthey Bishop Inc., and Pittsburgh Plate Glass Industries.

Disposal of Facilities

The AEC announced on June 2, 1969 that it would not dispose of the Redox chemical processing facility located at Hanford after discussions with companies interested in Redox revealed that economic factors would only permit them to offer nominal bids for the plant.[5]

Atomic Energy Community Disposal

The disposal of three Government-owned communities—Oak Ridge, Tenn., Richland, Wash., and Los Alamos, N. Mex., which were built for the World War II atomic bomb effort—has been virtually completed. In 1969, there are few vestiges of the once complete Government control of the communities.

[5] See p. 273, "Annual Report to Congress for 1968."

Before establishment of the AEC—during the wartime Manhattan Project—Oak Ridge, Richland, and Los Alamos were wholly Government-owned and controlled; few inhabitants even knew the real nature of the "home industry"—or even its end-products. In 1955, Congress passed the Atomic Energy Community Act which permitted the Government to get out of the community business at Oak Ridge and Richland. The Act was amended in 1962 to include Los Alamos disposal.

At Los Alamos, the latest of the communities to be disposed of to individual purchasers or municipal entities; four small remnants of AEC control remain: (*a*) The Fire Department, which serves both the AEC's Los Alamos Scientific Laboratory (LASL) and the community; (*b*) 64 apartments retained to house graduate students at LASL; (*c*) utility or other auxiliary facilities in the technical areas; and (*d*) Federal financial assistance to the Los Alamos County and the Los Alamos school board. With the sale of the last of 14,000 Government-owned properties, in the three cities, net proceeds to the Government should total $85 million when final. Los Alamos properties should return about $21 million to the U.S. Treasury. Thus ends a 14-year sales effort of properties appraised at $106 million.

A Safe Touchdown in Albuquerque Scores More Savings for U.S. taxpayers. The radio controlled trimotor model plane (*above*), built by the AEC's Sandia Laboratories, made it possible for researchers to conduct scale-model experiments more often and at less expense than using conventional, piloted aircraft. The model plane system gives tremendous flexibility to Sandia's test programs. It affords unlimited practice to operators of tracking telescopes; it carries pressure gauges over high explosive tests; and it is used to drop brightly painted dummy units as tracking targets for motion picture cameras. Recent use of the model plane is just one of several hundred innovations which have been developed throughout the AEC since the inception of the Cost-Reduction Program in 1964. In 1969, AEC and its contractors reported more than 5,000 deliberate actions resulting in savings of over $60 million which were applied to other approved programs and activities. Over the period 1964 to 1969 the total savings were about $350 million, or an average of $70 million attributable to 3,000 deliberate actions a year.

RADIATION EXPOSURE RECORDS

The establishment of a central repository for radiation exposure records was realized during 1969 through the centralizing of certain radiation exposure information required to be maintained by AEC contractors and licensees. In November 1968 the AEC had approved a requirement[6] for the reporting of radiation exposures to a central repository by AEC contractors who are exempt from licensing, and four categories of licensees.

Central Record Repository

The central records repository has been established at the Computing Technology Center of the AEC's Oak Ridge (Tenn.) Operations Office. The yearend status of the repository indicates that 231,000 individuals (including 63,000 visitors) were monitored during 1968. thus were required to be reported (in accordance with § 20.407). Licensee and contractor termination reports have been submitted on 7,100 employees. Of this number 32 percent left their jobs within 3 months of their date of employment, and 5 percent terminated within 4 to 6 months of their date of employment, for a total of 37 percent terminating within 6 months of date of employment.

Pilot Recordkeeping Program

During the year, the AEC has been exploring with several States their interest in participating in a pilot recordkeeping program to provide the Oak Ridge central repository with occupational exposure information from users of radiation sources not under AEC jurisdiction. Arrangements covering participation in this pilot program have been entered into with the States of Maryland, Georgia, Illinois, Wyoming, and Utah. The contribution of Illinois promises to be substantial since the State has had a centralized records and reports system in operation since 1964. Several other States have expressed a

[6] See *Federal Register* for 1968, Vol. 33, No. 246, pp. 18926–18927. Implementation of this requirement took the form of an amendment to 10 CFR Part 20 which became effective on February 17, 1969, and which was subsequently modified on March 14, 1969 (*Federal Register*, Vol. 34, No. 50, p. 5254) to extend the 30-day time limit for filing reports on terminated employees to 30 days after exposure of the individual has been determined by the licensee or 90 days following termination of employment or work assignment, whichever is sooner. On March 12, 1969, the AEC extended similar requirements to its operating contractors.

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willingness to explore participation in the AEC's pilot program (Arizona, California, Colorado, Delaware, and Pennsylvania). Discussions with these States are underway.

The American Bar Association (ABA) at its annual meeting in August 1969, by Resolution of its House of Delegates, endorsed in principle the efforts of the AEC in urging States to require employers to keep records as to employees' exposure to radiation and to provide for a central repository of occupational radiation exposure information. The report of the Radiation Committee of the International Association of Industrial Accident Boards and Commissions, filed during the September annual meeting of the association, recommended that States give serious consideration to a system of recordkeeping of exposure to ionizing radiation.

Federal Agencies

The U.S. Public Health Service (PHS) is furnishing for incorporation in the central repository, identification and cumulative exposure information at termination of employment of individuals employed in PHS facilities as well as for those Federal agencies for whom PHS provides a film dosimetry service. Discussions are underway to obtain similar information with the three branches of the military service, the Veterans Administration, and the U.S. Department of Agriculture.

Workmen's Compensation Standards

During the year, the AEC has continued to work closely with the States to improve their workmen's compensation laws. A total of 46 amendments in 20 States were introduced and of these, 17 have been enacted. The number of States, including Puerto Rico and the District of Columbia now meeting the AEC's 11 standards are:

Review of lump sum settlements	52
Radiation injury coverage	49
Extraterritoriality	47
Authority to review medical care	45
Adequate time limit	42
Waivers prohibited	41
Full medical and physical rehabilitation coverage	39
Compulsory law	31
No numerical exemption	28
Vocational rehabilitation	28
Broad second injury fund	26

The AEC has worked closely with the Atomic Energy Law Committee of the American Bar Association (ABA) which has been active in seeking support of State officials and local bar associations in those States where there is a need for enactment of legislation relating to three of the above standards. In August of 1969, the House of Delegates of the ABA adopted a resolution recommending that all workmen's compensation acts should provide: (*a*) Coverage for all employees who sustain injuries as a result of exposure to ionizing radiation in their employment; and (*b*) full coverage for medical services reasonably necessary in the treatment of injuries resulting from ionizing radiation.[7]

While the AEC has supported the traditional role of preserving State jurisdiction in the workmen's compensation field, the charge of ineffective State legislative action has been heard this year from within the State establishment itself. On May 1, 1969, the Governor of Rhode Island approved a resolution of the Rhode Island State Legislature memorializing the U.S. Congress to establish a Federal Workmen's Compensation Law because " . . . Dissatisfaction with the adequacy and administration of State workmen's compensation laws has become widespread." In 1969, a bill similar to the Rhode Island resolution was introduced in the Oklahoma legislature. However, the bill died in committee. Congressional interest in the subject of workmen's compensation continues, as evidenced by a Senate Bill (S. 1106) to establish a national commission to study and evaluate State workmen's compensation laws; and a House Bill (H.R. 6780) to authorize grants for improved administration of research and training in the workmen's compensation field.

Radiation Cases

In view of the difficulties associated with the causal relation problem in latent radiation claims, the AEC is currently in the process of conducting a study encompassing the review of cases involving exposure to ionizing radiation (X-ray, radium, radon, atomic energy materials, etc.) assembled during the past 2 years. A preliminary analysis of the review indicates that exposure records play an important role in deciding the issue of causation.

CONTRACTING POLICY

The AEC took positive action during 1969 on nearly all of a procurement procedures study group's[8] recommendations, including is-

[7] In 1968, the ABA adopted a resolution recommending that the time limit for filing a radiation claim should start when the employee knows, or should know, that the disability or injury may be caused by radiation. In case of death the time for filing a claim should not begin to run until the time of death.

[8] See pp. 294–295, "Annual Report to Congress for 1967."

suance of revised procurement regulations clarifying AEC policy and requirements for administration of contractor procurement activities. The seven-man group, which had been appointed in 1967, made an extensive study of the procurement process in AEC programs and submitted its final report [9] in December 1968. While the group noted that AEC contractor procurement has been well done, it also concluded there was a trend toward too much control by the AEC over its contractor procurement which tended to limit use of contractor management ability and flexibility in conducting procurement activities.

Procurement and Contracting Training

During 1969, an outline of basic objectives and guidelines proposed for AEC field office and contractor training programs in procurement and contracting was developed and issued. These objectives and guidelines are designed to meet the need for courses, conferences, or seminars which would: (*a*) Make procurement and related staff people more closely identify with program missions; (*b*) stress the importance to good purchasing of comprehensive interchanges between all staffs involved—engineer and scientist requisitioners, attorneys, and financial as well as procurement personnel; and (*c*) provide a practical means of obtaining training in procurement procedures such as through the use of case examples drawn from actual AEC transactions (rather than just through a study of procurement regulations and policies).

GAO Report on AEC Equipment Management

On March 14, 1969, the Government's General Accounting Office (GAO) reported that "for the most part, GAO found the policies, procedures, and practices provided a system for managing equipment in an effective manner." The AEC has taken action to make GAO-suggested improvements to obtain more effective use of some stored and infrequently used equipment by closer surveillance in storage, greater use of pools, and more frequent walk-through inspections and onsite reviews.

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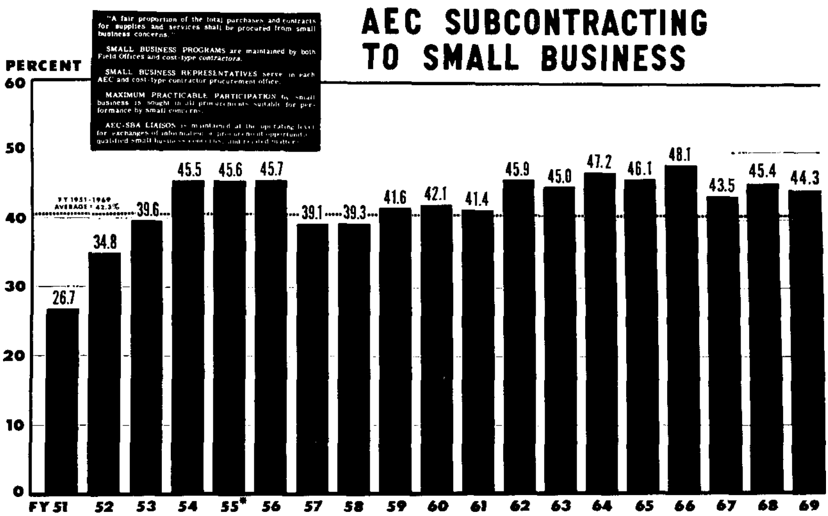
[9] "Report of Study of Administration of Procurement and Contracting Procedures of Major Cost-type Contractors," November 1968, is available in the AEC's Public Document Room, 1717 H St., N.W., Washington, D.C.



	FY 51	52	53	54	55*	56	57	58	59	60	61	62	63	64	65	66	67	68	69
SUBCONTRACT DOLLARS TO SMALL BUSINESS (Millions of Dollars)	209.7	259.0	311.6	241.2	153.9	211.1	224.3	216.0	220.5	262.9	277.4	338.0	334.9	364.9	312.3	312.9	280.0	349.5	372.3
SUBCONTRACT DOLLARS - TOTAL	785.5	743.5	783.0	529.0	337.9	461.8	574.2	550.0	530.3	624.0	669.2	736.0	744.5	772.8	677.3	650.9	643.5	770.3	841.8

* Does not include three Kiewit Co. Subcontracts at Portsmouth, Ohio which are in the nature of prime contracts.

AEC Subcontracting to Small Business

The AEC continues to encourage and assist small business participation in its prime contracts and subcontracts. During 1969, AEC prime contractors awarded over $372 million of $842 million or 44 percent of their subcontracts to small business concerns. AEC assistance to small business has averaged 42 percent of subcontract awards during the period 1951 through 1969.

A program for placing AEC business with minority business enterprise was intensified in 1969 by: (*a*) Making visits to selected minority firms to more fully explore their capabilities to provide products and services needed by the AEC and its contractors; and (*b*) identifying candidate items suitable for referral to the Small Business Administration for possible procurement from minority firms under Section 8(a) of the Small Business Act.

BOARD OF CONTRACT APPEALS

The Board of Contract Appeals (see appendix 2 for membership list) is the authorized representative of the Commission to hear, consider, and decide appeals arising under AEC prime contracts and certain subcontracts and to conduct debarment hearings and decide debarment cases in which a hearing has been held. The board's rules are published in 10 CFR Part 3. The board sits in three-member panels except in accelerated proceedings when either the chairman or vice chairman sits alone. During the 5-year period of its existence the Board of Contract Appeals has docketed 66 appeals and one special proceeding. The board has been able to dispose of appeals without accumulation of a backlog and has achieved settlement in over 65 percent of the cases appealed to it. Only one appeal has been the subject of a court suit.

The board actively encourages and participates with the parties in disposing of disputes by agreement as an important means of resolving contract disputes. As a result of this policy, stronger efforts are being exerted by contracting officers to dispose of disputes by agreement without the necessity of appeal proceedings.

Use of pretrial conference techniques has been primarily responsible for the increasing disposition by agreement of appealed disputes. A primary purpose of conferences is to bring the parties together informally to consider disposing of their dispute by agreement.

The accelerated procedure may be used when the amount in dispute does not exceed $10,000 or for other good causes. It provides for the consideration and disposition of appeals without regard to their normal position on the docket and continues to aid in expeditious resolution of appeals.

In 1969 as in prior years, the board made every effort to accommodate small businesses in promptly granting the accelerated procedure and in holding conferences and hearings at or near the location of the small business. This was done to avoid hardships which administrative proceedings may cause small businesses.

The board disposes of both accelerated and nonaccelerated appeals without unnecessary delay. The average period of pendency for accelerated proceedings is 83 days and for nonaccelerated proceedings is 142 days.

APPENDIX 1

ORGANIZATION AND PRINCIPAL STAFF OF U.S. ATOMIC ENERGY COMMISSION

COMMISSIONERS

Atomic Energy Commission	GLENN T. SEABORG, *Chairman*
	JULIUS H. RUBIN, *Special Assistant*
	JAMES T. RAMEY
	ALEX G. FREMLING, *Special Assistant*
	WILFRID E. JOHNSON
	GERARD F. HELFRICH, *Technical Assistant*
	THEOS J. THOMPSON
	JACK ROSEN, *Special Assistant*
	CLARENCE E. LARSON
	JOHN A. GRIFFIN, *Special Assistant*
Secretary to the Commission	W. B. MCCOOL
Controller	JOHN P. ABBADESSA
General Counsel	JOSEPH F. HENNESSEY
Director of Inspection	GEORGE E. HUBBELL (Acting)
Chief Hearing Examiner	SAMUEL W. JENSCH
Chairman, AEC Board of Contract Appeals	PAUL H. GANTT
Chairman, Atomic Safety and Licensing Board Panel	ALGIE A. WELLS

OPERATING FUNCTIONS*

General Manager	ROBERT E. HOLLINGSWORTH
Executive Assistant to the General Manager	DONALD C. KULL
Assistant to the General Manager	HARRY S. TRAYNOR
Assistant to the General Manager for Program Analysis	ROGER W. A. LEGASSIE
Assistant for Equal Employment Opportunity Programs	MARION A. BOWDEN
Special Assistant to the General Manager for Environmental Affairs	JOSEPH J. DINUNNO
Special Assistant to the General Manager	JOHN C. RYAN
Deputy General Manager	EDWARD J. BLOCH
Assistant General Manager	HOWARD C. BROWN, JR.
Director, Division of Industrial Participation	ERNEST B. TREMMEL
Director, Division of Intelligence	C. H. REICHARDT
Director, Division of Public Information	JOHN A. HARRIS
Director, Office of Congressional Relations	ROBERT D. O'NEILL
Special Assistant for Disarmament	ALLAN M. LABOWITZ

*The AEC's official mailing address is: U.S. Atomic Energy Commission, Washington, D.C. 20545. Mail addressed thusly will reach the proper Headquarters staff whether located at the AEC's main building in Germantown, Md., the Bethesda, Md., offices (Phillips Bldg., 7920 Norfolk Ave.), or the Washington, D.C. offices (1717 H St., N.W.).

Assistant General Manager for Operations	JOHN A. ERLEWINE
Assistant for Economic and Community Affairs	GEORGE J. KETO
Assistant for Workmen's Compensation and Radiation Records	CHARLES F. EASON
Director, Division of Construction	JOHN A. DERRY
Director, Division of Contracts	JOSEPH L. SMITH
Director, Division of Labor Relations	H. T. HERRICK
Director, Division of Operational Safety	MARTIN B. BILES
Assistant General Manager for Research and Development	SPOFFORD G. ENGLISH
Director, Division of Biology and Medicine	JOHN R. TOTTER
Director, Division of Isotopes Development	E. EUGENE FOWLER
Director, Division of Nuclear Education and Training	RUSSELL S. POOR
Director, Division of Peaceful Nuclear Explosives	JOHN S. KELLY
Director, Division of Research	PAUL W. MCDANIEL
Assistant General Manager for Plans and Production	GEORGE F. QUINN
Director, Division of Operations Analysis and Forecasting	PAUL C. FINE
Director, Division of Plans and Reports	WILLIAM H. SLATON
Director, Division of Production	F. P. BARANOWSKI
Director, Division of Raw Materials	RAFFORD L. FAULKNER
Assistant General Manager for Reactors	GEORGE M. KAVANAGH
Director, Division of Naval Reactors	VAdm. H. G. RICKOVER, USN
Director, Division of Reactor Development and Technology	MILTON SHAW
Director, Division of Space Nuclear Systems	MILTON KLEIN
Assistant General Manager for International Activities and Director, Division of International Affairs	MYRON B. KRATZER
Assistant General Manager for Administration	JOHN V. VINCIGUERRA
Director, Division of Classification	CHARLES L. MARSHALL
Director, Division of Headquarters Services	EDWARD H. GLADE
Director, Division of Personnel	DONALD E. BOSTOCK
Director, Division of Security	WILLIAM T. RILEY
Director, Division of Technical Information	EDWARD J. BRUNENKANT
Assistant General Manager for Military Application and Director, Division of Military Application	Maj. Gen. EDWARD B. GILLER, USAF
Director, Office of Safeguards and Materials Management	DELMAR L. CROWSON

Addresses and Managers of Field Offices

Albuquerque Operations Office Post Office Box 5400 Albuquerque, N. Mex. 87115	HAROLD C. DONNELLY
Amarillo Area Office Post Office Box 1086 Amarillo, Tex. 79105	J. DURWOOD YATES
Burlington Area Office Post Office Box 561 Burlington, Iowa 52602	ELBERT W. GILES
Dayton Area Office Post Office Box 66 Miamisburg, Ohio 45342	WILLIS B. CREAMER
Kansas City Area Office Post Office Box 202 Kansas City, Mo. 64141	HENRY A. NOWAK
Los Alamos Area Office Los Alamos, N. Mex. 87544	H. J. BLACKWELL

Pinellas Area Office Post Office Box 11500 St. Petersburg, Fla. 33733	WALTER C. YOUNGS, Jr.
Rocky Flats Area Office Post Office Box 928 Golden, Colo. 80402	FRANK E. ABBOTT
Sandia Area Office Post Office Box 5400 Albuquerque, N. Mex. 77115	LADDIE W. OTOSKI
Brookhaven Office Upton, Long Island, N.Y. 11973	E. L. VAN HORN
Chicago Operations Office 9800 South Cass Avenue Argonne, Ill. 60439	KENNETH A. DUNBAR
200 Bev. Accelerator Facility Office Post Office Box 500 Batavia, Ill. 60510	KENNEDY C. BROOKS
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Nevada Operations Office Post Office Box 14100 Las Vegas, Nev. 89114	ROBERT E. MILLER
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Paducah Area Office Post Office Box 1213 Paducah, Ky. 42002	BERNARD N. STILLER
Portsmouth Area Office Piketon, Ohio 45661	ROY V. ANDERSON
Puerto Rico Area Office Post Office Box BB Hato Rey, Puerto Rico 00919	J. PERRY MORGAN

Pittsburgh Naval Reactors Office Post Office Box 109 West Mifflin, Pa. 15122	LAWTON D. GEIGER
Richland Operations Office Post Office Box 550 Richland, Wash. 99352	DONALD G. WILLIAMS
San Francisco Operations Office 2111 Bancroft Way Berkeley, Calif. 94704	ELLISON C. SHUTE
Palo Alto Area Office Post Office Box 2370 Stanford, Calif. 94305	HOWARD C. HOOPER
Savannah River Operations Office Post Office Box A Aiken, S.C. 29801	NATHANIEL STETSON
Schenectady Naval Reactors Office Post Office Box 1069 Schenectady, N.Y. 12301	STANLEY W. NITZMAN

AEC Scientific Representatives Abroad

Bombay, India	HAROLD F. MCDUFFIE, JR.
Brussels, Belgium	R. GLENN BRADLEY, *Senior Representative*
Buenos Aires, Argentina	ROBERT H. GOECKERMANN
Chalk River, Ontario, Canada	ROBERT W. RAMSEY, JR.
London, England	WILLIAM L. R. RICE
Paris, France	JOSEPH D. LAFLEUR
Rio de Janeiro, Brazil	ROBERT H. WILCOX
Tokyo, Japan	WHITTIE J. MCCOOL

LICENSING AND REGULATORY FUNCTIONS*

Director of Regulation	HAROLD L. PRICE
Deputy Director	CLIFFORD K. BECK
Assistant Director for Reactors	M. M. MANN
Assistant Director for Administration	C. L. HENDERSON
Director, Division of Compliance	LAWRENCE D. LOW
Director, Division of Reactor Licensing	PETER A. MORRIS
Director, Division of Reactor Standards	EDSON G. CASE
Director, Division of Radiation Protection Standards	LESTER R. ROGERS
Director, Division of Materials Licensing	JOHN A. MCBRIDE
Director, Division of State and Licensee Relations	EBER R. PRICE
Director, Division of Nuclear Materials Safeguards	RUSSELL P. WISCHOW

Addresses and Directors of Compliance Regional Offices

Region I (New York) 970 Broad Street Newark, N.J. 07102	ROBERT W. KIRKMAN
Region II (Atlanta) Suite 818 230 Peachtree Street, NW. Atlanta, Ga. 30303	JOHN G. DAVIS
Region III (Chicago) 799 Roosevelt Road Glen Ellyn, Ill. 60137	BOYCE H. GRIER

* See footnote on p. 281.

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Denver, Colo. 80215

Region V (San Francisco) ---------------------------------- RICHARD W. SMITH
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Berkeley, Calif. 94704

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Newark, N.J. 07102

District II (Oak Ridge) ---------------------------------- WILLIAM B. KENNA
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Oak Ridge, Tenn. 37830

District III (San Francisco) ---------------------------------- VINCENT N. RIZZOLO
2111 Bancroft Way
Berkeley, Calif. 94704

APPENDIX 2

MEMBERSHIP OF COMMITTEES, ETC., DURING 1969

STATUTORY COMMITTEES AND BOARDS

Joint Committee on Atomic Energy—91st Congress (First Session)

The Joint Committee on Atomic Energy was established by the Atomic Energy Act of 1946, and continued under Section 201 of 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 nine Members of the Senate and nine Members of the House of Representatives. During 1969, the committee was composed of:

Representative CHET HOLIFIELD (California), *Chairman*
Senator JOHN O. PASTORE (Rhode Island), *Vice Chairman*
Senator RICHARD B. RUSSELL (Georgia)
Senator CLINTON P. ANDERSON (New Mexico)
Senator ALBERT GORE (Tennessee)
Senator HENRY M. JACKSON (Washington)
Senator GEORGE D. AIKEN (Vermont)
Senator WALLACE F. BENNETT (Utah)
Senator CARL T. CURTIS (Nebraska)
Senator NORRIS COTTON (New Hampshire)
Representative MELVIN PRICE (Illinois)
Representative WAYNE N. ASPINALL (Colorado)
Representative JOHN YOUNG (Texas)
Representative CRAIG HOSMER (California)
Representative JOHN B. ANDERSON (Illinois)
Representative WILLIAM M. MCCULLOCH (Ohio)
Representative ED EDMONDSON (Oklahoma)
Representative CATHERINE MAY (Washington)
EDWARD J. BAUSER, *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 (*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. CARL WALSKE, *Chairman*
Maj. Gen. OTTO J. GLASSER, United States Air Force
RAdm. ROBERT E. RIERA, United States Navy
Brig. Gen. KENNETH F. DAWALT, United States Army
Brig. Gen. RICHARD L. AULT, United States Air Force
Brig. Gen. WILLIAM W. STONE, Jr., United States Army
Capt. JAMES G. WHITEAKER, United States Navy

General Advisory Committee

The AEC's General Advisory Committee was established by the Atomic Energy Act of 1946, and is continued by Section 26 of 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. The committee meets at least four times in every calendar year and annually designates one of its own members as chairman.

HOWARD G. VESPER, *Chairman;* retired (formerly Vice President, Standard Oil Co. of California, San Francisco, Calif.)
Dr. JOHN C. BUGHER, retired (formerly Director, Puerto Rico Nuclear Center, San Juan, P.R.)
Dr. HERBERT FRIEDMAN, Superintendent, Space Science Division, U.S. Naval Research Laboratory, Washington, D.C.
Dr. EDWIN L. GOLDWASSER, Deputy Director, National Accelerator Laboratory, Batavia, Ill.
Dr. JANE H. HALL, Assistant Director, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. STEPHEN LAWROSKI, Associate Director, Argonne National Laboratory, Argonne, Ill.
Dr. NORMAN F. RAMSEY, Professor of Physics, Harvard University, Cambridge, Mass.
LOMBARD SQUIRES, retired (formerly Assistant General Manager, Explosives Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.), Naples, Fla.
WILLIAM WEBSTER, Chairman, New England Electric System, Boston, Mass.
Dr. MELVIN A. HARRISON, Scientific Officer; Lawrence Radiation Laboratory, Livermore, Calif.
ANTHONY A. TOMEI, *Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee met four times in 1969: at Oak Ridge, Tenn., on February 10–12; in Washington, D.C., on April 23–25; at Idaho Falls, Idaho, on July 29–31; and in Washington, D.C., on November 10–12.

Patent Compensation Board

The Patent Compensation 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, patent attorney, Toledo, Ohio.
HERMAN I. HERSH, firm of McDougall, Hersh, Scott, & Ladd, Chicago, Ill.
LAWRENCE C. KINGSLAND, firm of Kingsland, Rogers, Ezell, Ellers & Robbins, St. Louis, Mo.

The board met four times in 1969; at Washington, D.C., on February 10–13, March 26–29, May 12–14, and December 2–3.

Advisory Committee on Reactor Safeguards

The Advisory Committee on Reactor Safeguards established under Section 29 of the Atomic Energy Act of 1954, as amended, 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 4 years each, and one member is designated by the committee as its chairman. This committee was established as a statutory body in 1957.

Dr. STEPHEN H. HANAUER, *Chairman;* Professor of Nuclear Engineering, University of Tennessee, Knoxville, Tenn.

Dr. JOSEPH M. HENDRIE, *Vice Chairman;* Physicist, Brookhaven National Laboratory, Upton, N.Y.

Dr. SPENCER H. BUSH, Consultant to Director (Metallurgy), Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Wash.

HAROLD ETHERINGTON, Consulting Engineer (Mechanical Reactor Engineering), Jupiter, Fla.

HIBBERT M. HILL, Consultant (Hydraulic Engineering and Lake Biology), Excelsior, Minn.

Dr. HERBERT S. ISBIN, Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn.

Dr. WARREN J. KAUFMAN, Professor of Sanitary Engineering, University of California, Richmond, Calif.

HAROLD G. MANGELSDORF, Chairman of the Board, Crown Central Petroleum Corp., Short Hills, N.J.

Dr. HARRY O. MONSON, Senior Engineer, Laboratory Director's Office, Argonne National Laboratory, Argonne, Ill.

Dr. ARLIE A. O'KELLY, Consultant (Industrial Chemistry), Littleton, Colo.

Dr. DAVID OKRENT, Senior Physicist, Laboratory Director's Office, Argonne National Laboratory, Argonne, Ill.

Dr. CHESTER P. SIESS, Professor of Civil Engineering, University of Illinois, Urbana, Ill.

LOMBARD SQUIRES, Consultant (Chemical Engineering), (formerly Assistant General Manager, Explosives Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.), Naples, Fla.

Dr. WILLIAM R. STRATTON, Physicist, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

The committee met 13 times in 1969; at Washington, D.C., on January 9–11, February 6–8, March 6–8, April 10–12, May 2, May 8–10, June 5–7, July 10–12, August 7–9, September 4–6, October 9–11, November 6–8, and December 11–13.

Atomic Safety and Licensing Board Panel

Section 191 of the Atomic Energy Act of 1954 authorizes, in addition to other matters, the Commission to establish one or more atomic safety and licensing boards, each to be composed of three members, two of whom are to be technically qualified and one of whom is to be qualified in the conduct of administrative proceedings. Technically qualified alternates may be appointed to atomic safety and licensing boards, to serve in the event that a board member should become unavailable before the start of a hearing. The boards 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. The Atomic Safety and Licensing Board Panel office, with a permanent chairman and vice chairman, coordinates and supervises the ASLB activities; serves as spokesman for the panel; and presents recommendations to the Commission relating to the conduct of hearings, hearing procedures, and policies for the guidance of the boards. The Commission has appointed the following panel to serve on atomic safety and licensing boards as assigned.

A. A. WELLS, *Panel Chairman,* U.S. Atomic Energy Commission, Washington, D.C.

Dr. JOHN H. BUCK, *Panel Vice Chairman,* U.S. Atomic Energy Commission, Washington, D.C.

J. D. BOND, Retired Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

R. B. BRIGGS, Director, Molten Salt Reactor Program, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. A. DIXON CALLIHAN, Union Carbide Corp., Oak Ridge, Tenn.

JACK M. CAMPBELL, Partner in law firm of Stephenson, Campbell & Olmstead, Santa Fe, N. Mex.

VALENTINE B. DEALE, Attorney-at-law, Washington, D.C.

Dr. MILTON C. EDLUND, Director, Middle East Study Group, Oak Ridge, Tenn.

Dr. ROLF ELIASSEN, Professor of Environmental Engineering, Stanford University, Palo Alto, Calif.

Dr. STUART GORDON FORBES, TRW Systems, Redondo Beach, Calif.

Dr. JOHN C. GEYER, Chairman, Department of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore, Md.

JAMES P. GLEASON, Attorney-at-law, Washington, D.C.

Dr. CLARK GOODMAN, Professor of Physics and Department Chairman, University of Houston, Houston, Tex.

Dr. EUGENE GREULING, Professor of Physics, Duke University, Durham, N.C.

Dr. DAVID B. HALL, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

SAMUEL W. JENSCH, Chief Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

ARTHUR W. MURPHY, Columbia University School of Law, New York City.

Dr. HUGH PAXTON, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. THOMAS H. PIGFORD, Professor of Nuclear Engineering, University of California, Berkeley, Calif.

Dr. LAWRENCE R. QUARLES, Dean, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va.

Dr. CLARKE WILLIAMS, Research Administrator, Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board, Hauppauge, Long Island, N.Y.

Dr. CHARLES E. WINTERS, Union Carbide Corp., Washington, D.C.

Dr. ABEL WOLMAN, The Johns Hopkins University, Baltimore, Md.

HOOD WORTHINGTON, retired, E. I. du Pont de Nemours Co. Scientist and Administrator, Wilmington, Del.

JAMES R. YORE, *Panel Executive Secretary*, U.S. Atomic Energy Commission, Washington, D.C.

Eight new boards were drawn from the panel in 1969 for regulatory proceedings. A general ASLB panel meeting was held with the AEC Commissioners on July 8–9 at Oak Ridge, Tenn., and numerous meetings on specific problems were held with groups of panel members throughout the year.

APPEALS BOARDS

Atomic Safety and Licensing Appeal Board

An Atomic Safety and Licensing Appeal Board was established by the Commission, effective September 18, 1969, and the Commission delegated to it the authority to perform the functions which would otherwise be performed by the Commission in: (*a*) those proceedings on applications for licenses or authorizations in which the Commission has a direct financial interest, and (*b*) such other licensing proceedings as the Commission may specify. The Appeal Board is comprised of the Chairman and Vice Chairman of the Atomic Safety and Licensing Board Panel and a third, technically qualified member who is designated by the Commission for each proceeding.

A. A. WELLS, *Appeals Board Chairman;* U.S. Atomic Energy Commission, Washington, D.C.

Dr. JOHN H. BUCK, *Appeals Board Vice Chairman;* U.S. Atomic Energy Commission, Washington, D.C.

Third Member of Appeal Board designated by the Commission for each proceeding.

The board reviewed one proceeding during 1969.

Board of Contract Appeals

On August 25, 1964, the Commission established the AEC Board of Contract Appeals under the supervision of a chairman, who reports directly to the Commission. The Board of Contract Appeals considers and finally decides appeals from findings of fact or decisions of contracting officers in disputes arising under AEC prime contracts containing a disputes provision and certain subcontracts containing such a provision. The board, in addition, conducts hearings and finally decides debarment cases in which a hearing has been held. The rules of practice of the board were published in the *Federal Register* on September 11, 1964, and codified as part 3 of Title 10, Code of Federal Regulations.

PAUL H. GANTT, *Board Chairman;* U.S. Atomic Energy Commission, Washington, D.C.

JOHN G. ROBERTS, *Board Vice Chairman;* U.S. Atomic Energy Commission, Washington, D.C.

CARMINE S. BELLINO, Certified Public Accountant, Wright, Long & Co., Washington, D.C.

LAWRENCE R. CARUSO, Legal Counsel, Office of Research Administration, Princeton University, Princeton, N.J.
VALENTINE B. DEALE, Attorney at Law, Washington, D.C.
Dr. G. KENNETH GREEN, Chairman, Accelerator Department, Brookhaven National Laboratory, Upton, N.Y.
HENRY B. KEISER, Attorney at Law and President, Federal Publications, Inc., Washington, D.C.
LEONARD J. KOCH, Director, Reactor Engineering Division, Argonne National Laboratory, Argonne, Ill.
JOHN A. MCINTIRE, Consulting Attorney, Office of Judge Advocate General, U.S. Navy, Washington, D.C.
RALPH C. NASH, Jr., Associate Dean for Graduate Studies, Research and Projects of National Law Center, George Washington University, Washington, D.C.
THOMAS J. O'TOOLE, Dean, Northeastern School of Law, Boston, Mass.
HAROLD C. PETROWITZ, Professor of Law, Washington College of Law, American University, Washington, D.C.
CHARLES G. SONNEN, Private Consultant, Oak Ridge, Tenn.
JOHN M. STOY, Certified Public Accountant, Stoy, Malone & Co., Washington, D.C.
ARLENE TUCK ULMAN, Attorney at Law, Washington, D.C.
ROBERT M. UNDERHILL, Vice President and Treasurer Emeritus, University of California, Berkeley, Calif.
JOHN W. WHELAN, Professor of Law, University of California at Davis School of Law, Davis, Calif.

Eight panels were designated to hear, consider, and decide appeals during 1969.

ADVISORY BODIES TO THE ATOMIC ENERGY COMMISSION

Atomic Energy Labor-Management Advisory Committee

The Atomic Energy Labor-Management Advisory Committee was established in March 1962 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. Its charter was expanded in 1963 to permit consideration of questions other than those concerned with the radiological aspects of industrial safety.

H. T. HERRICK, *Chairman;* Director, Division of Labor Relations, U.S. Atomic Energy Commission, Washington, D.C.
C. L. HENDERSON, *Vice Chairman;* Assistant Director of Regulation for Administration, U.S. Atomic Energy Commission, Washington, D.C.
ANDREW J. BIEMILLER, Director, Department of Legislation, AFL–CIO, Washington, D.C.
H. ROY CHOPE, Executive Vice President for Development and Engineering, Industrial Nucleonics Corp., Columbus, Ohio
HAROLD A. FIDLER, Associate Director, Lawrence Radiation Laboratory, Berkeley, Calif.
CHARLES D. HARRINGTON, President, Douglas United Nuclear, Inc., Richland, Wash.
CHARLES H. KEENAN, Vice President, Yankee Atomic Electric Co., Boston, Mass.
HOWARD K. NASON, President, Monsanto Research Corp., St. Louis, Mo.
CHARLES H. PILLARD, International President, International Brotherhood of Electrical Workers, Washington, D.C.
PETER T. SCHOEMANN, General President, United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada, Washington, D.C.
FLOYD E. SMITH, International President, International Association of Machinists and Aerospace Workers, Washington, D.C.
ELWOOD D. SWISHER, Vice President, Oil, Chemical and Atomic Workers International Union, Denver, Colo.

The committee met twice in 1969: at Washington, D.C., on May 15 and November 25.

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. EARL L. GREEN, *Chairman;* Director, The Jackson Laboratory, Bar Harbor, Maine
Dr. PHILIP P. COHEN, *Vice Chairman;* Professor and Chairman, Department of Physiological Chemistry, University of Wisconsin School of Medicine, Madison, Wis.

Dr. WILLIAM F. BALE, Professor, Radiation Biology, Department of Radiation Biology and Biophysics; and Atomic Energy Project, University of Rochester, School of Medicine and Dentistry, Rochester, N.Y.

Dr. ARIE J. HAAGEN-SMIT, Professor, Division of Biology, California Institute of Technology, Pasadena, Calif.

Dr. ROBERT D. MOSELEY, Jr., Chairman of Department of Radiology, University of Chicago, Chicago, Ill.

Dr. LEMUEL C. MCGEE, Medical Director, Hercules, Inc., Wilmington, Del.

Dr. MORRELL B. RUSSELL, Director, Agricultural Experiment Station, University of Illinois, Urbana, Ill.

Dr. HARVEY M. PATT, *Scientific Secretary*, Director, Laboratory of Radiobiology, San Francisco Medical Center, University of California, San Francisco, Calif.

ROSEMARY ELMO, *Executive Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee met four times in 1969: at Washington, D.C., January 10–11; Cleveland, Ohio, May 2–3; Washington, D.C., September 12–13; and at Aiken, S.C., on November 14–15.

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. ALFRED D. CHANDLER, *Chairman;* Professor of History, The Johns Hopkins University, Baltimore, Md.

Dr. LAUCHLIN M. CURRIE, Engineer, Carmel, Calif.

Dr. A. HUNTER DUPREE, Professor of History, Brown University, Providence, R.I.

Dr. ERNEST R. MAY, Dean of the College and Professor of History, Harvard University, Cambridge, Mass.

Dr. ROBERT P. MULTHAUF, Senior Historian of Science, Museum of History and Technology, Smithsonian Institution, Washington, D.C.

JOHN T. CONWAY, Executive Assistant to the Chairman, Consolidated Edison Co. of New York, Inc., New York, N.Y.

Dr. RICHARD G. HEWLETT, AEC representative, Chief Historian, U.S. Atomic Energy Commission, Washington, D.C.

The committee met once in 1969 at Washington, D.C., on December 8.

Advisory Committee on Isotopes and Radiation Development

The Advisory Committee on Isotopes and Radiation Development was established by the Commission in July 1958 to advise on means of encouraging wide-scale industrial use of radioisotopes and nuclear radiation.

JOHN W. LANDIS, *Chairman;* Regional Vice President, Gulf General Atomics, Inc., Washington, D.C.

Dr. NATHANIEL F. BARR, U.S. Atomic Energy Commission, Washington, D.C.

Dr. MERRILL A. BENDER, Chief, Department of Nuclear Medicine, Roswell Park Memorial Institute, Buffalo, N.Y.

Dr. MILTON BURTON, Director of Radiation Laboratory, University of Notre Dame, Notre Dame, Ind.

Dr. MERRIL EISENBUD, Administrator, Environmental Protection Administration, New York, N.Y.

Dr. BERNARD FRIES, Senior Research Associate, Chevron Research Co., Richmond, Calif.

Dr. DAVID E. HARMER, Head, Gamma Radiation Section, Radiochemistry Research Laboratory, Dow Chemical Co., Midland, Mich.

ROBERT E. KETTNER, President, Nuclear Assurance Corp., Atlanta, Ga.

Dr. IRA LON MORGAN, Director, Center for Nuclear Studies, University of Texas, Austin, Tex.

LYLE E. PACKARD, President, Packard Instrument Co., Inc., Chicago, Ill.

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*"*Atomic Shield, 1947–1952*," the second volume in the AEC historical series was published in October 1969. Written by the AEC's historical staff, the book includes 45 photographs and is available from bookstores or from The Pennsylvania State University Press, University Park, Pa. 16802, at $11.95. Volume I of the series, "*The New World, 1939–1946*," is also available from Penn State at $9.50. The publisher is also issuing a boxed set of both volumes at $17.95.

Dr. A. J. RESTAINO, Manager, Polymer Section, Chemical Research Department of Atlas Chemical Industries, Inc., Wilmington, Del.
Dr. SEYMOUR ROTHCHILD, President, New England Nuclear Corp., Boston, Mass.

The committee met twice during 1969: at the Savannah River Laboratories, Aiken, S.C. on March 17–18; and at AEC Headquarters, Germantown, Md., on November 6–7.

Advisory Committee on Medical Uses of Isotopes

The Advisory Committee on Medical Uses of Isotopes was established in 1958 and replaced the Subcommittee on Human Applications of the Advisory Committee on Isotope Distribution. The committee advises the Commission on policies and standards for the regulation and licensing of medical uses of radioisotopes in humans.

Dr. JOHN A. MCBRIDE, *Chairman;* Director, Division of Materials Licensing, U.S. Atomic Energy Commission, Washington, D.C.
Dr. MERRILL A. BENDER, Chief, Department of Nuclear Medicine, Roswell Park Memorial Institute, Buffalo, N.Y.
Dr. JOHN E. CHRISTIAN, Head of Bionucleonics, Purdue University, Lafayette, Ind.
Dr. DAVID E. KUHL, Associate Professor of Radiology, University of Pennsylvania, School of Medicine, Philadelphia, Pa.
Dr. GEORGE V. LEROY, Medical Director, Metropolitan Hospital, Detroit, Mich.
Dr. JAMES L. QUINN III, Director, Nuclear Medicine Department, Chicago Wesley Memorial Hospital, Chicago, Ill.
Dr. HARALD ROSSI, Professor of Radiology, College of Physicians and Surgeons, Columbia University, New York, N.Y.
Dr. ROBERT J. SHALEK, Head, Department of Physics, M.D. Anderson Hospital and Tumor Institute, University of Texas, Houston, Tex.
Dr. HENRY N. WAGNER, Professor of Radiology and Radiological Science, The Johns Hopkins Medical Institutions, Baltimore, Md.
Dr. CHARLES D. WEST, Associate Research Professor of Biology, University of Utah, College of Medicine, Salt Lake City, Utah.
Dr. JOSEPH B. WORKMAN, Head, Nuclear Medicine Laboratory, University of Maryland Hospital, Baltimore, Md.

The committee met once during 1969: at Washington, D.C., on April 26.

Advisory Committee on Nuclear Materials Safeguards

The Advisory Committee on Nuclear Materials Safeguards was established August 29, 1967, to assist the AEC in carrying out more effectively its responsibilities for safeguarding special nuclear materials under the Atomic Energy Act. The committee advises the Commission in the development of: policy regarding safeguards against the diversion of special nuclear materials; safeguards standards and criteria; safeguards procedures; safeguards research and development; methods of measurement and other procedures; and standard reference materials. On request, the advisory committee provides technical advice relating to safeguards standards and criteria regarding specific problems involving licensee or contractor operations and on other matters that may be pertinent.

JOHN PALFREY, *Chairman;* Professor of Law, Columbia University, New York City.
Brig. Gen. DELMAR L. CROWSON (USAF, Ret.), *Vice Chairman;* Director, Office of Safeguards and Materials Management, U.S. Atomic Energy Commission, Washington, D.C.
Dr. RUSSELL P. WISCHOW, *Vice Chairman;* Director, Division of Nuclear Materials Safeguards, U.S. Atomic Energy Commission, Washington, D.C.
Dr. ROGER E. BATZEL, Associate Director, Lawrence Radiation Laboratory, Livermore, Calif.
FRANCIS P. COTTER, Vice President, Westinghouse Electric Corp., Washington, D.C.
Dr. JANE HALL, Associate Director, Los Alamos (N. Mex.) Scientific Laboratory.
Dr. HORACE W. NORTON, III, Professor, University of Illinois, Urbana, Ill.
Dr. NORMAN F. RAMSEY, Higgins Professor of Physics, Lyman Laboratory of Physics, Harvard University, Cambridge, Mass.
Dr. CLEMENT J. RODDEN, Manager, AEC's New Brunswick (N.J.) Area Office and Director of the New Brunswick Laboratory.
Dr. CHARLES D. W. THORNTON, Executive Vice President, Clevepak Corp., Cleveland, Ohio.
Dr. FRED H. TINGEY, Manager, Technical Services Division, Idaho Nuclear Corp., Idaho Falls, Idaho.

Dr. FRANCIS O. WILCOX, Dean, School of Advanced International Studies, Johns Hopkins University, Baltimore, Md.

Dr. J. ERNEST WILKINS, Jr., Assistant Director, Gulf General Atomics, Inc., San Diego, Calif.

JOHN T. CONWAY, Executive Assistant to the Chairman of the Board, Consolidated Edison of New York, New York City.

BRUCE F. SMITH, Price-Waterhouse & Co., New York City.

ASHTON O'DONNELL, Bechtel Corp., San Francisco, Calif.

Dr. HERBERT J. SCOVILLE, Jr., Brookings Institution, Washington, D.C.

Dr. MANSON BENEDICT, Head, Nuclear Engineering Dept., Massachusetts Institute of Technology, Cambridge, Mass.

The committee held two meetings during 1969: at Los Alamos Scientific Laboratory and at the Gulf General Atomic Facilities in San Diego, on May 14–17, in the AEC's offices in Washington, D.C., on December 10 and 11.

Advisory Committee on Reactor Physics

The Advisory Committee on Reactor Physics was established in 1951 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 are reviewed and evaluated. The committee's recommendations and advice are used in planning research and development work in the field of reactor physics.

Dr. WILLIAM H. HANNUM, *Chairman;* Division of Reactor Development and Technology, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ROBERT AVERY, Director, Reactor Physics Division, Argonne National Laboratory, Argonne, Ill.

Dr. ROBERT T. BAYARD, Westinghouse Electric Corp., Bettis Atomic Power Laboratory, Pittsburgh, Pa.

Dr. D. K. BUTLER, LMFBR Program Office, Argonne National Laboratory, Argonne, Ill.

JACK CHERNICK, Associate Head, Reactor Physics Division, Brookhaven National Laboratory, Upton, Long Island, N.Y.

Dr. FRANK G. DAWSON, Jr., Manager, Reactor Physics Department, Pacific Northwest Laboratory, Richland, Wash.

DESLONDE R. DEBOISBLANC, EBASCO, New York, N.Y.

Dr. GERHARD DESSAUER, Director, Physics Section, E. I. duPont de Nemours & Co., Aiken, S.C.

Dr. RICHARD EHRLICH, Manager, Advanced Development Activity, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N.Y.

Dr. E. R. GAERTTNER, Director, Linac Project, Rensselaer Polytechnic Institute, Troy, N.Y.

Dr. GORDON HANSEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. ALLAN F. HENRY, Department of Nuclear Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. F. C. MAIENSCHEIN, Director, Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. HARRY MOREWITZ, Atomics International, Canoga Park, Calif.

Dr. LOTHAR W. NORDHEIM, Consultant, Theoretical Physics Department, Gulf General Atomic, San Diego, Calif.

Dr. THOMA M. SNYDER, Consultant, Advanced Engineering, Department of Reactor Fuels & Reprocessing, General Electric Co., San Jose, Calif.

Dr. ALVIN RADKOWSKY, *Secretary;* Division of Naval Reactors, U.S. Atomic Energy Commission, Washington, D.C.

The committee met twice in 1969: at Oak Ridge, Tenn., January 22–23; and at Upton, L.I., N.Y., on June 11–12.

Committee of Senior Reviewers

The Committee of Senior Reviewers studies the major technical activities of the AEC's programs and advises the Commission on classification and declassification matters, making recommendations with respect to the classification rules and guides for the control of scientific and technical information.

Dr. WARREN C. JOHNSON, *Chairman;* retired Vice President for Special Scientific Programs, University of Chicago, Chicago, Ill.

Dr. EUGENE EYSTER, Alternate GMX Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

ROBERT W. HENDERSON, Vice President, Sandia Corp., Albuquerque, N. Mex.
Dr. J. CARSON MARK, T Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. J. REGINALD RICHARDSON, Professor of Physics, University of California at Los Angeles, Calif.
Dr. JACK W. ROSENGREN, Associate Director for Nuclear Design, Lawrence Radiation Laboratory, Livermore, Calif.
PAUL R. VANSTRUM, Vice President, Union Carbide Corp., Nuclear Division, Oak Ridge, Tenn.

The committee met twice in 1969: at Las Vegas, Nev., on January 22–23 and at Livermore, Calif., on June 16. In addition, the committee made orientation trips during the year to plants and facilities located in Livermore, Los Alamos, Richland (Wash.), and the Nevada Test Site.

Standing Committee for Controlled Thermonuclear Research

The Commission, on June 21, 1966, established a Standing Committee for Controlled Thermonuclear Research. This committee reviews, on a continuing basis, the AEC's controlled thermonuclear program and provides advice and recommendations to the Division of Research and the Commission relative to the program. The committee was established to ensure closer cooperative effort within the program and to provide guidance on implementing major program decisions. The committee has four members who are directors of the controlled thermonuclear research in their respective laboratories and four members from the scientific community outside of the AEC and its major laboratories.

Dr. AMASA S. BISHOP, *Chairman;* Assistant Director for Controlled Thermonuclear Research, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.
Dr. KEITH A. BRUECKNER, University of California, San Diego, Calif.
Dr. SOLOMON J. BUCHSBAUM, Sandia Corp., Albuquerque, N. Mex.
Dr. H. R. CRANE, University of Michigan, Ann Arbor, Mich.
Dr. WILLIAM A. FOWLER, California Institute of Technology, Pasadena, Calif.
Dr. MELVIN B. GOTTLIEB, Plasma Physics Laboratory, Princeton University, Princeton, N.J.
Dr. HERMAN POSTMA, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Dr. RICHARD F. TASCHEK, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. CHESTER VAN ATTA, Lawrence Radiation Laboratory, Livermore, Calif.

The committee met five times in 1969: at Los Alamos, N. Mex., on January 14–15; at Princeton, N.J., on March 19–20; at Livermore, Calif., on April 15–16; at Albuquerque, N. Mex., on June 26–28; and at Oak Ridge, Tenn., on October 15–16.

High Energy Physics Advisory Panel

The High Energy Physics Advisory Panel was established in November 1966 pursuant to the provisions of Section 161a of the Atomic Energy Act, to review on a continuing basis, the high energy physics research program and to provide advice and recommendations to the Division of Research with respect to this program.

Prof. V. F. WEISSKOPF, *Chairman;* Massachusetts Institute of Technology, Cambridge, Mass.
Dr. RODNEY L. COOL, Brookhaven National Laboratory, Upton, N.Y.
Dr. BRUCE CORK, Argonne National Laboratory, Argonne, Ill.
Prof. LEON LEDERMAN, Columbia University, Nevis Laboratories, Irvington, N.Y.
Dr. EDWARD J. LOFGREN, Lawrence Radiation Laboratory, Berkeley, Calif.
Dr. GEORGE E. PAKE, Washington University, St. Louis, Mo.
Prof. W. K. H. PANOFSKY, Stanford Linear Accelerator Center, Stanford University, Stanford, Calif.
Prof. A. PEVSNER, Johns Hopkins University, Baltimore, Md.
Dr. JAMES R. SANFORD, National Accelerator Laboratory, Batavia, Ill.
Dr. ANDREW SESSLER, Lawrence Radiation Laboratory, Berkeley, Calif.
Prof. KENT TERWILLIGER, University of Michigan, Ann Arbor, Mich.
Prof. SAM B. TREIMAN, Princeton University, Princeton, N.J.
Prof. WILLIAM J. WILLIS, Yale University, New Haven, Conn.
Dr. GERALD F. TAPE, Associated Universities Incorporated, Washington, D.C.
Dr. BERNARD HILDEBRAND, *Executive Secretary;* Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

The panel met four times during 1969: at Cambridge, Mass., on January 31–February 1; at Palo Alto, Calif., on May 23–24; at Washington, D.C., on October 13–14; and at Brookhaven National Laboratory, December 7–9.

Mathematics and Computer Sciences Research Advisory Committee

The Mathematics and Computer Sciences Research Advisory Committee was established in 1960 as an advisory board to the Division of Research of the AEC to make recommendations on computer research and development programs and provide advice and guidance on problems in this field.

Dr. YOSHIO SHIMAMOTO, *Chairman;* Brookhaven National Laboratory, Upton, N.Y.
Dr. MARIO L. JUNCOSA, The Rand Corp., Santa Monica, Calif.
Prof. FREDERICK P. BROOKS, Univ. of North Carolina, Chapel Hill, N.C.
Prof. GERALD ESTRIN, Department of Engineering, University of Calif. at Los Angeles, Calif.
Dr. SIDNEY FERNBACH, Computation Division, Lawrence Radiation Laboratory, Univ. of Calif., Livermore, Calif.
Dr. PAUL R. GARABEDIAN, AEC Computing and Applied Mathematics Center, Courant Institute of Mathematical Sciences, New York Univ., N.Y.
Dr. J. WALLACE GIVENS, Jr., Applied Mathematics Division, Argonne National Laboratory, Argonne, Ill.
Dr. ALSTON S. HOUSEHOLDER, University of Tenn., Knoxville, Tenn.
Dr. JOHN R. PASTA, University of Ill., Urbana, Ill.
Dr. ROGER LAZARUS, *Secretary;* Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

The committee met twice during 1969: at Palo Alto, Calif., on March 17; and at Idaho Falls, Idaho, on October 6.

Nuclear Cross Sections Advisory Committee

The Nuclear Cross Sections Advisory Committee provides consultation and guidance for the AEC's program of nuclear cross-section measurements. Information from this program is of fundamental importance to many activities of the AEC.

Dr. MICHAEL S. MOORE, *Chairman;* Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. HARRY ALTER, Atomics International, Canoga Park, Calif.
Dr. ROBERT C. BLOCK, Rensselaer Polytechnic Institute, Troy, N.Y.
Dr. CHARLES D. BOWMAN, Lawrence Radiation Laboratory, Livermore, Calif.
Dr. ROBERT M. BRUGGER, Idaho Nuclear Corp., Idaho Falls, Idaho.
Dr. FRANK FEINER, Knolls Atomic Power Laboratory, Schenectady, N.Y.
Dr. JOHN H. GIBBONS, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Prof. HERBERT GOLDSTEIN, Columbia University, New York, N.Y.
Dr. MARVIN H. KALOS, Defense Atomic Support Agency, Washington, D.C.
PHILIP B. HEMMIG, Division of Reactor Development and Technology, U.S. Atomic Energy Commission, Washington, D.C.
Dr. HAROLD E. JACKSON, Argonne National Laboratory, Argonne, Ill.
Dr. HARRY H. LANDON, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C.
Prof. HENRY W. NEWSON, Duke University, Durham, N.C.
Prof. GERALD C. PHILLIPS, Rice University, Houston, Tex.
Dr. GEORGE L. ROGOSA, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.
Dr. ROBERT E. CHRIEN, *Secretary;* Brookhaven National Laboratory, Upton, N.Y.

The committee met twice in 1969: at Oak Ridge, Tenn., on April 15–17; and Houston, Tex., on September 18–19.

Personnel Security Review Board

The Personnel Security Review 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. This 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.

JOHN J. WILSON, *Chairman,* Washington, D.C.
C. FRANK REIFSNYDER, Washington, D.C.
LOUIS A. TURNER, Princeton, N.J.

The board reviewed and made recommendations to the General Manager on six cases during 1969.

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.
WILLARD BASCOM, President, Ocean Science and Engineering, Inc., Long Beach, Calif.
Lt. Gen. JAMES H. DOOLITTLE, Los Angeles, Calif.
Dr. LOUIS H. HEMPELMANN, University of Rochester, Rochester, N.Y.
Dr. RICHARD LATTER, The Rand Corp., Santa Monica, Calif.
Dr. WILLARD F. LIBBY, University of California at Los Angeles, Calif.
Dr. DONALD H. MCLAUGHLIN, Chairman of the Board, Homestake Mining Co., San Francisco, Calif.
JOHN G. PALFREY, Professor of Law, Columbia University, New York City.
Dr. PHILIP C. RUTLEDGE, Partner, Mueser, Rutledge, Wentworth & Johnson, New York, N.Y.
Dr. PAUL B. SEARS, Las Milpas, Taos, N. Mex.
Dr. HYMER L. FRIEDELL, Western Reserve University, Cleveland, Ohio.
Lt. Gen. ALFRED D. STARBIRD, Commanding General, U.S. Army Safeguard Systems Office, Arlington, Va.
JOHN S. KELLY, *Secretary*, Director, Division of Peaceful Nuclear Explosives, U.S. Atomic Energy Commission, Washington, D.C.

The committee met once in 1969: at the E. O. Lawrence Radiation Laboratory, Livermore, Calif., on November 4–5.

Advisory Committee on Technical Information

The Advisory Committee on Technical Information 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.
LEON N. ALBERT, President, Prentice-Hall International, Inc., Englewood Cliffs, N.J.
CARROLL G. BOWEN, President, Franklin Book Programs, Inc., New York, N.Y.
JOHN E. DOBBIN, Project Director, Educational Testing Service, Princeton, N.J.
JAMES L. GAYLORD, Senior Partner of James L. Gaylord Associates, Pacific Palisades, Calif.
Dr. ALLEN G. GRAY, Director, Periodical Publications, American Society for Metals, Metals Park, Ohio.
KARL T. SCHWARTZWALDER, Director of Research and Development, A-C Spark Plug Division, General Motors Corp., Flint, Mich., representing the American Ceramic Society, Inc., Columbus, Ohio.
JOHN W. WIGHT, Vice President for Marketing, McGraw-Hill Book Co., Inc., New York, N.Y.

The committee did not meet in 1969.

Technical Information Panel

The Technical Information Panel was established in 1948 to advise and assist the AEC in the planning, testing, development, and execution of the Commission's technical information program, primarily on matters of interest to the National Laboratories and major operating contractors.

EDWARD J. BRUNENKANT, *Chairman;* Director, Division of Technical Information, U.S. Atomic Energy Commission, Washington, D.C.
J. C. BARTON, Superintendent, Laboratory Division, Union Carbide Corp., Oak Ridge, Tenn.
ROBERT A. BENSON, Technical Editor, Monsanto Research Corp., Mound Laboratory, Miamisburg, Ohio.
CLARENCE T. BROCKETT, Head, Technical Information Department, Lawrence Radiation Laboratory, Livermore, Calif.
JAMES W. CONDER, Technical Information, Dow Chemical Co., Golden, Colo.

JOHN E. DAVIS, Senior Administrative Assistant, Department of Materials Engineering, Battelle Memorial Institute, Columbus, Ohio.
W. E. DREESZEN, Head, Information and Security, Ames Laboratory, Ames, Iowa.
DOROTHY M. DUKE, Technical Librarian, Atomic Energy Division, the Babcock & Wilcox Co., Lynchburg, Va.
Dr. C. P. KEIM, Director, Technical Information Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.
MAX K. LINN, Director of Information, Sandia Corp., Sandia Base, Albuquerque, N. Mex.
FRANK R. LONG, General Supervisor, Information Services, Atomics International, Canoga Park, Calif.
JOHN H. MARTENS, Director, Technical Publications Department, Argonne National Laboratory, Argonne, Ill.
Dr. JUDD C. NEVENZEL, University of California, Laboratory of Nuclear Medicine, Los Angeles, Calif.
STEWARD W. O'REAR, Supervisor, Technical Information Service, E. I. du Pont de Nemours & Co. Savannah River Lab., Aiken, S.C.
GEORGE E. OWENS, Head, Technical Information Dept., Standard Linear Accelerator Center, Palo Alto, Calif.
HARRY P. PEARSON, Director, Technical Information, Idaho Nuclear Corp., Idaho Falls, Idaho.
A. D. PEPMUELLER, Manager, Technical Information Department, Sandia Corp., Livermore, Calif.
DENNIS PULESTON, Head, Information Division, Brookhaven National Laboratory, Upton, N.Y.
HELEN F. REDMAN, Librarian, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
VIRGINIA STERNBERG, Supervisor, Bettis Technical Information, Westinghouse Electric Corp., West Mifflin, Pa.
C. G. STEVENSON, Technical Information Section Manager, Pacific Northwest Laboratory, Richland, Wash.
Dr. STUART STURGES, Manager, Technical Information, Knolls Atomic Power Laboratory, Schenectady, N.Y.
CHARLES D. TABOR, Assistant Manager, Technical Division, Goodyear Atomic Corp., Piketon, Ohio.
JOSEPH W. VOTAW, Assistant to Technical Director, National Lead Co. of Ohio, Cincinnati, Ohio.
Dr. RAYMOND K. WAKERLING, Chief, Technical Information Division, Lawrence Radiation Laboratory, Berkeley, Calif.
ROBERT L. SHANNON, *Secretary;* Ext. Manager, Division of Technical Information Extension, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

The panel met once in 1969; at Bethesda, Md., on November 5–6.

APPENDIX 3

MAJOR AEC-OWNED, CONTRACTOR-OPERATED INSTALLATIONS [1]

AMES LABORATORY (Iowa State University of Science and Technology, contractor), Ames, Iowa

Director	Dr. Robert S. Hansen
Deputy Director	Dr. Velmer A. Fassel
Assistant Director	Dr. Adolf F. Voigt

ARGONNE NATIONAL LABORATORY (University of Chicago and Argonne Universities Association, contractors), Argonne, Ill.

Director	Dr. Robert B. Duffield
Deputy Director	Dr. Michael V. Nevitt
Associate Director	Dr. Stephen Lawroski
Associate Director	Dr. Winston M. Manning
Associate Director	Dr. Bruce Cork
Associate Director	Dr. Shelby A. Miller

The University of Chicago

President	Edward H. Levi
Vice President, Programs and Projects	William B. Cannon

Argonne Universities Association [2]

Chairman, Board of Trustees	Dr. Norman Hackerman
President	Dr. Philip N. Powers

BETTIS ATOMIC POWER LABORATORY (Westinghouse Electric Corp., contractor), Pittsburgh, Pa.

General Manager	N. A. Beldecos
Manager, Operations	E. J. Kreh
Manager, Operating Plants	W. H. Hamilton

BROOKHAVEN NATIONAL LABORATORY (Associated Universities, Inc., contractor), Upton, N.Y.

Laboratory Director	Dr. Maurice Goldhaber
Deputy Director	Dr. George Vineyard
Associate Director	Dr. Victor P. Bond
Associate Director	Dr. Rodney L. Cool

Associated Universities, Inc. [2]

Chairman, Board of Trustees	Dr. F. A. Long
President, AUI	Dr. Gerald F. Tape

BURLINGTON AEC PLANT (Mason & Hanger-Silas Mason Co., Inc., contractor) Burlington, Iowa

Contract Manager (Vice President)	R. B. Jewell
Plant Manager	D. E. Heffelbower
Administration & Services Division Manager	R. S. Ramsey
Engineering Division Manager	C. R. Poole
Manufacturing Division Manager	P. D. Holliday
Quality and Reliability Division Manager	R. L. Holmberg

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[1] Installations and prime contractors where the AEC's total combined investment in plant and equipment exceeds $25 million are listed here. Other research and development installations are listed in App. 1 of the supplementary report, "Fundamental Nuclear Energy Research—1969."

[2] Associations or groups of educational institutions participating in AEC facility operations or programs are listed in App. 1 of the supplementary report, "Fundamental Nuclear Energy Research—1969."

CAMBRIDGE ELECTRON ACCELERATOR (Massachusetts Institute of Technology and Harvard University, contractor), Cambridge, Mass.

Director	Dr. KARL STRAUCH
Assistant Director	Dr. GUSTAV A. VOSS
Business Manager	WILLIAM B. BALCH

FEED MATERIALS PROUCTION CENTER (National Lead Co. of Ohio, contractor), Fernald, Ohio

Manager	JAMES H. NOYES
Assistant Manager	M. S. NELSON

HANFORD FACILITIES (eight contractors—Atlantic Richfield, Battelle-Northwest, Computer Sciences Corp., Douglas United Nuclear, Hanford Engineering Services, Hanford Environmental Health Foundation, ITT Federal Support Services, J. A. Jones Construction), Richland, Wash.

Atlantic Richfield Hanford Co., Richland, Wash.

President	Dr. L. M. RICHARDS
Vice President, Operations	R. P. CORLEW
Vice President, Business Management	E. T. MCINTYRE

Computer Sciences Corp., Northwest Operations, Richland, Wash.

Director	H. L. LEONE
Executive Assistant	Z. E. CAREY
Manager, Finance and Administration	A. S. TERRY

Douglas United Nuclear, Inc., Richland, Wash.

President and General Manager	Dr. CHARLES D. HARRINGTON
Vice President and Deputy General Manager	RAYMON W. HALLET, Jr.
Vice President and Assistant General Manager for Operation Division	O. C. SCHROEDER
Vice President and Assistant General Manager for Technical Division	Dr. CARL W. KUHLMAN
Director, Legal and Employee Relations Division	WILLIAM G. CATTS
Director, Finance and Administration Division	KENNETH L. ROBERTSON

Hanford Engineering Services, Richland, Wash.

President	J. M. FRAME
General Manager	GEORGE KLIGFIELD

Hanford Environmental Health Foundation, Richland, Wash.

Medical Director	P. A. FUQUA, M.D.
Asst. Medical Director	G. H. CROOK, M.D.
Manager, Finance and Contract Administration	A. R. ADELINE
Manager, Environment Sciences Department	F. E. ADLEY

ITT Federal Support Services, Richland, Wash.

Executive Vice President and General Manager	T. P. LEDDY
Manager, Purchasing and Stores	W. M. HUNT
Manager, Transportation and Maintenance	M. F. RICE
Manager, Plant Protection, Services, and Utilities	C. W. WEEKS

J. A. Jones Construction Co., Richland, Wash.

General Manager and Vice President	IRA E. DUNN
Assistant Manager	D. L. SHORT

Pacific Northwest Laboratory (Battelle-Northwest Division of Battelle Memorial Institute, Columbus, Ohio, contractor), Richland, Wash.

Director	Dr. F. W. ALBAUGH
Associate Director	W. D. RICHMOND
Associate Director	Dr. BERTRAM WOLFE
Assistant Director, Finance and Administration Division	WALLACE SALE
Assistant Director, Safety and Standards Division	Dr. J. J. CADWELL
Assistant Director, Technical Services Division	F. W. WOODFIELD
Chief Counsel and Manager, Sponsor Development and Legal Division	SAM J. FARMER
Manager, Chemistry and Metallurgy Division	Dr. D. R. DEHALAS

Manager, Environmental and Life Sciences Division	Dr. EDWARD L. ALPEN
Manager, Fast Flux Test Facility Division	E. R. ASTLEY
Manager, Physics and Engineering Division	F. G. DAWSON
Manager, Systems and Electronics Division	Dr. C. A. BENNETT

KANSAS CITY PLANT (The Bendix Corp., Kansas City Division, contractor) Kansas City, Mo.

General Manager	R. J. QUIRK
Assistant General Manager	V. L. RITTER
Director, Manufacturing	F. J. TAYLOR
Director, Engineering	D. J. NIGG

KNOLLS ATOMIC POWER LABORATORY (General Electric Co., contractor) Schenectady, N.Y.

General Manager	H. E. STONE
Manager, A1G Project	C. S. HOFMANN
Manager, Nuclear Plant Engineering	E. C. RUMBAUGH
Manager, Operating Nuclear Plants	D. J. ANTHONY
Manager, Kesselring Site Operation	L. H. WEINBERG

E. O. LAWRENCE RADIATION LABORATORY (University of California, contractor), facilities at Berkeley and Livermore, Calif.

Director	Dr. EDWIN M. MCMILLAN
Director, Livermore Laboratory	Dr. MICHAEL M. MAY
Business Manager	RICHARD P. CONNELL
Deputy Business Manager	WILLIAM B. HARFORD

Associate Directors, Berkeley:

Donner Laboratory of Medical Physics, Director	Dr. JOHN H. LAWRENCE
Inorganic Materials Research Division	Dr. LEO BREWER
Laboratory of Chemical Biodynamics, Director	Dr. MELVIN CALVIN
Nuclear Chemistry Division	Dr. ISADORE PERLMAN
Physics Division	Dr. DAVID L. JUDD
Program and Planning	Dr. ROBERT L. THORNTON
Administration	Dr. HAROLD A. FIDLER
Support	Dr. ELMER L. KELLY

Associate Directors, Livermore:

Biomedical Research & Chemistry	Dr. ROGER E. BATZEL
Military Applications	Dr. CHARLES A. MCDONALD
Nuclear Design	Dr. ARTHUR T. BIEHL
Nuclear Testing	Dr. HARRY L. REYNOLDS
Physics	Dr. EDWARD TELLER
Plans	A. CARL HAUSSMANN
Plowshare	Dr. GLENN C. WERTH
Sherwood	Dr. CHESTER M. VAN ATTA
Special Projects	Dr. JACK W. ROSENGREN
Support	DUANE C. SEWELL

LOS ALAMOS SCIENTIFIC LABORATORY (University of California, contractor), Los Alamos, N. Mex.

Director	Dr. NORRIS E. BRADBURY
Technical Associate Director	Dr. RAEMER E. SCHREIBER
Assistant Director	Dr. JANE H. HALL
Assistant Director, Production	Dr. MAX F. ROY
Assistant Director, Classification and Security	PHILLIP F. BELCHER
Assistant Director, Financial Planning	LESLIE G. HAWKINS
Assistant Director, Administration	HENRY R. HOYT

MOUND LABORATORY (Monsanto Research Corp., contractor), Miamisburg, Ohio

Project Director (President, Monsanto Research Corp.)	H. K. NASON
Director, Mound Laboratory	RALPH L. NEUBERT
Director, Nuclear Operations	G. RICHARD GROVE
Director, Explosives Operations	J. E. BRADLEY

NATIONAL ACCELERATOR LABORATORY (Universities Research Association, contractor) Batavia, Ill.

Director	Dr. ROBERT R. WILSON
Deputy Director	Dr. EDWIN L. GOLDWASSER
Associate Director	Dr. STANLEY M. LIVINGSTON
Associate Director	Dr. THOMAS L. COLLINS
Associate Director	Dr. FRANCIS T. COLE
Assistant Director	DONALD GETZ

NATIONAL REACTOR TESTING STATION (NRTS) (four contractors—Argonne National Laboratory, General Electric, Idaho Nuclear, and Westinghouse), Idaho Falls, Idaho

Argonne National Laboratory (Idaho Facilities), Idaho Falls

Assistant Laboratory Director	MEYER NOVICK
Assistant Business Manager	DONALD F. WOOD
Deputy Director, Reactor Physics Division	FREDERICK W. THALGOTT
EBR–2 Reactor Operations Superintendent	Dr. HARRY LAWROSKI

General Electric Co. (Knolls Atomic Power Laboratory, S5G Field Office), Idaho Falls

Manager, S5G Test Plant Site	E. H. SCHOCH

Idaho Nuclear Corp. (Jointly owned subsidiary of Aerojet General Corp., Allied Chemical Corp., and Phillips Petroleum Co.), Idaho Falls

President	C. M. RICE
Vice President	W. E. NYER
Vice President and Assistant General Manager, Technical	F. H. ANDERSON
Assistant General Manager, Administration	J. P. LYON

Westinghouse Electric Corp., Idaho Falls

Manager, Naval Reactor Facility	H. D. RUPPEL
Assistant to Manager, NRF	M. W. WALCHER
Manager, A4W Shutdown	W. H. MCKIM
Manager, Administrative Services	W. H. WALKER
Manager, Training Naval Reactors Facility	G. R. LOCKARD
Manager, S1W Plant	L. P. DUFFY
Manager, A1W Plant	D. F. BOLENDER
Manager, Expended Core Facility	T. A. MANGELSDORF
Manager, Plant Support	D. E. AKEY
Manager, Quality Assurance	C. WILLIAMS
Manager, Radiation Engineering	C. S. ABRAMS
Controller, Naval Reactors Facility	J. L. TAYLOR

NEVADA TEST SITE (Reynolds Electrical & Engineering Co., contractor), Mercury, Nev.

General Manager	R. W. KIEHN (Acting)
Deputy General Manager	R. W. KIEHN
Administration Division	R. E. GILLETT
Program Control Division	W. A. STEVENS
Operations Division	R. D. CUNNINGHAM
Site Facilities Division	R. A. SMITH

NUCLEAR ROCKET DEVELOPMENT STATION (Los Alamos Scientific Laboratory, Pan American World Airways, Inc., Westinghouse Electric Corp., contractor), Jackass Flats, Nev.

OAK RIDGE RESEARCH AND DEVELOPMENT AND PRODUCTION FACILITIES (Union Carbide Corp., Nuclear Division, contractor), Oak Ridge, Tenn., and Paducah, Ky.

President, Union Carbide Corp., Nuclear Division	R. F. HIBBS

Oak Ridge Production Facilities

Vice President—Production, Union Carbide Corp., Nuclear Division	P. R. VANSTRUM
Superintendent, Y–12 Plant	J. M. CASE
Superintendent, Oak Ridge Gaseous Diffusion Plant	ROBERT G. JORDAN
Superintendent, Paducah Gaseous Diffusion Plant	ROBERT A. WINKEL

Oak Ridge National Laboratory

Director (Vice President, Union Carbide Corp., Nuclear Division)	Dr. ALVIN M. WEINBERG
Deputy Director	Dr. H. G. MACPHERSON

PANTEX PLANT (Mason & Hanger-Silas Mason Co., contractor), Amarillo, Tex.

Contract Manager (Vice President)	R. B. Jewell
Plant Manager	John C. Drummond
Division Manager, Engineering	Marion L. Ott
Division Manager, Manufacturing	Robert B. Carroll

PORTSMOUTH GASEOUS DIFFUSION PLANT (Goodyear Atomic Corp., contractor), Piketon, Ohio

General Manager	C. H. Reynolds
Deputy General Manager	Charles Tabor

PRINCETON-PENNSYLVANIA ACCELERATOR (Princeton University and University of Pennsylvania, contractors), *James Forrestal Research Center, Princeton, N.J.*

Director	Dr. Milton G. White
Associate Director	Dr. Walter Wales
Assistant Director	Dr. Alfred K. Mann

PRINCETON PLASMA PHYSICS LABORATORY (Princeton University, contractor), James Forrestal Research Center, Princeton, N.J.

Director	Dr. Melvin B. Gottlieb
Associate Director	Dr. Edward A. Frieman
Assistant Director	Dr. E. C. Tanner
Head, Experimental Division	Dr. Tom Stix
Head, Engineering and Development Division	Dr. Robert Mills
Head, Theoretical Division	Dr. J. M. Dawson
Head, Administrative Division	(Vacant)

ROCKY FLATS PLANT (Dow Chemical Co., contractor), Rocky Flats, Colo.

General Manager	Dr. Lloyd M. Joshel
Facilities Manager	Doyle M. Bassler
Quality Manager	Edward J. Walko
Controller	Clement H. Dompierre
Manufacturing Manager	Herbert E. Bowman
Industrial Relations Manager	Charles M. Love
Director of Research and Development	J. F. Willging
Division Services Manager	John G. Epp

SANDIA LABORATORY (Sandia Corp., contractor), facilities at Sandia Base, Albuquerque, N. Mex.; *Livermore, Calif.; and Tonopah, Nev.*

President	J. A. Hornbeck
Vice President	W. J. Howard
Vice President	R. W. Henderson
Vice President	R. B. Powell
Vice President	C. W. Campbell
Vice President	T. B. Cook, Jr.
Vice President	C. T. Ross, Jr.
Vice President	R. A. Bice
Vice President	S. J. Buchsbaum
Vice President	G. A. Fowler

SAVANNAH RIVER FACILITIES (E. I. du Pont de Nemours & Co., Explosives Department-Atomic Energy Division, Wilmington, Del., contractor)

Assistant General Manager	M. H. Wahl
Atomic Energy Division Manager	J. D. Ellett
Director of Manufacture	F. E. Kruesi
Director of Technical Division	J. W. Croach
Assistant Director, Technical Division	A. A. Johnson

E. I. du Pont de Nemours & Co. (Savannah River Plant, Aiken, S.C.)

Savannah River Operations

Plant Manager	J. A. Monier, Jr.
Assistant Plant Manager	K. W. French
General Superintendent, Works Technical Dept	W. P. Bebbington
General Superintendent, Production	J. K. Lower

Savannah River Laboratory

Director	C. H. Ice
Assistant Director	L. H. Meyer
Section Director—Physics Section	G. Dessauer
Section Director—Separations Chemistry & Engineering Section	H. J. Groh
Section Director—Nuclear Engineering and Materials Section	S. Mirshak
Section Director—Computer Sciences	J. E. Suich
Director, Professional and University Relations	J. W. Morris

STANFORD LINEAR ACCELERATOR CENTER (Stanford University, contractor), Palo Alto, Calif.

Director	Wolfgang K. H. Panofsky
Deputy Director	Sidney D. Drell
Associate Director, Technical Division	Richard B. Neal
Associate Director, Research Division	Joseph Ballam
Associate Director, Business Services Division	Frederick V. L. Pinder
Associate Director, Administrative Services Division	Robert H. Moulton, Jr.

APPENDIX 4

ANNOUNCED DEFENSE-RELATED UNDERGROUND NUCLEAR DETONATIONS, 1969 [1]

Name	*Date*	*Yield* [2]
BOWLINE Series (January–June)		
1. Packard	Jan. 15	Low.
2. Wineskin	Jan. 15	Low intermediate.
3. Vise	Jan. 30	Low intermediate.
4. Cypress	Feb. 12	Low.
5. Barsac	Mar. 20	Low.
6. Coffer	Mar. 21	Low intermediate.
7. Thistle	Apr. 30	Low intermediate.
8. Blenton	Apr. 30	Low intermediate.
9. Purse [3]	May 7	Low intermediate.
10. Torrido	May 27	Low intermediate.
11. Tapper	June 12	Low.
MANDREL Series (July–December)		
12. Ildrim	July 16	Low intermediate.
13. Hutch	July 16	Low intermediate.
14. Spider	Aug. 14	Low.
15. Pliers	Aug. 27	Low.
16. Minute Steak [4]	Sept. 12	Low.
17. Jorum [3]	Sept. 16	Intermediate.
18. Milrow [5]	Oct. 2	Low megaton.
19. Pipkin [3]	Oct. 8	Low intermediate.
20. Cruet	Oct. 29	Low.
21. Pod	Oct. 29	Low intermediate.
22. Calabash	Oct. 29	Low intermediate.
23. Piccalilli	Nov. 21	Low intermediate.
24. Diesel Train [4]	Dec. 5	Low.
25. Grape A	Dec. 17	Low intermediate.
26. Lovage	Dec. 17	Low.
27. Terrine	Dec. 18	Low intermediate.

[1] Plowshare (peaceful uses) program detonations are not included (see Chapter 11).

[2] Low yield, less than 20 kilotons (kt.); low intermediate yield, 20 to 200 kt.; intermediate yield, 200 kt. to 1 megaton (Mt.); and low megaton yield, one to several megatons.

[3] Conducted in the Pahute Mesa area of the NTS.

[4] DOD test conducted with AEC laboratory assistance.

[5] Conducted at Amchitka Island, Alaska.

APPENDIX 5

RULES AND REGULATIONS

The AEC's regulations are contained in Title 10, Chapter I of the Code of Federal Regulations. Effective and proposed regulations concerning licensed activities and published in the *Federal Register* during 1969 are set forth below.

REGULATIONS AND AMENDMENTS PUT INTO EFFECT

Atomic Safety and Licensing Appeal Board—Parts 1, 2, 50, and 115

On August 19, 1969, amendments to Parts 1 ("Statement of Organization, Delegations, and General Information"), 2 ("Rules of Practice"), 50 ("Licensing of Production and Utilization Facilities"), and 115 ("Procedures for Review of Certain Nuclear Reactors Exempted from Licensing Requirements") were published, effective September 18, 1969, which provided for the establishment of an Atomic Safety and Licensing Appeal Board to perform the Commission's review function, and certain Commission functions on interlocutory matters in: (*a*) such licensing proceedings as the Commission may specify and (*b*) proceedings on applications for licenses or authorizations for facilities in which the Commission has a direct financial interest. In proceedings other than those in which the Commission has a direct financial interest, the Commission reserved the right to review the appeal board's decision on its own motion, on certain specified grounds.

Copies of Applications for Facility Licenses—Parts 2 and 50

On April 3, 1969, amendments to Parts 2 and 50 were published, effective May 3, 1969, which increase the number of copies of an application for a facility license, including the amendments to the application, which must be submitted for different types of applications. The amendments also require that updated copies of applications for power and test reactors be served upon members of the Atomic Safety and Licensing Board designated to conduct the hearing, the Chairman of the Atomic Safety and Licensing Board Panel, the Director of the Division of Reactor Licensing, and the Secretary.

Elimination of Publication of Texts of Certain Licenses—Part 2

On June 21, 1969, the Commission published amendments to Part 2, effective July 21, 1969, which eliminated the requirement for publication of the text of proposed or issued licenses and amendments to licenses for facilities and for waste disposal activities.

Radioactive Wastes Licenses—Part 2

On July 25, 1969, amendments to Part 2 were published, effective August 24, 1969, which eliminated requirements for assignment of docket numbers, publication and notices of proposed action and issuance of licenses, and service of license applications and notices on state and local officials, with respect to applications for licenses to receive, package, or store radioactive wastes for transfer to other licensees for ultimate disposal.

AEC Jurisdiction—Interpretation of the General Counsel—Part 8

On May 3, 1969, an interpretation of the General Counsel was added to Part 8 ("Interpretations"), effective upon publication. The interpretation analyzed AEC jurisdiction over nuclear facilities and materials under the Atomic Energy Act, vis-a-vis the several States.

Public Records—Part 9

On June 26, 1969, amendments to Part 9 ("Public Records") were published, effective July 26, 1969. The amendments clarified the procedures by which members of the public may request copies of AEC records and payment therefor, and the procedures which AEC will follow in responding to such requests. Other corrective and clarifying changes were also made.

Reports of Loss or Theft of Licensed Material—Part 20

On May 9, 1969, an amendment to Part 20 ("Standards for Protection Against Radiation") was published, effective July 8, 1969, which requires a licensee to submit a written report of the loss or theft of licensed material in addition to the telephone and telegraph report previously required.

Reports of Personnel Exposure—Part 20

On March 14, 1969, an amendment to Part 20 was published, effective upon publication, which requires four specified categories of licensees to furnish to the AEC and terminated individuals reports of personnel exposure to radiation and radioactive material within 30 days after the exposure of the terminated individual has been determined by the licensee or 90 days after the date of termination of employment or work assignment, whichever is earlier.

Exemption of Electron Tubes—Parts 30, 31, and 32

On April 18, 1969, amendments to Parts 30 ("Rules of General Applicability to Licensing of Byproduct Material"), 31 ("General Licenses for Certain Quantities of Byproduct Material and Byproduct Material Contained in Certain Items"), and 32 ("Specific Licenses to Manufacture, Distribute, or Import Exempted and Generally Licensed Items Containing Byproduct Material") were published which: (*a*) Exempt from licensing requirements the possession and use of certain electron tubes containing byproduct material; (*b*) revoke the general license in Part 31 for spark gap and electronic tubes; (*c*) amend the requirements for issuance of specific licenses for the manufacture or import of certain items containing byproduct material; and (*d*) amend certain regulatory requirements applicable to holders of such licenses. The amendments to Parts 30 and 32 became effective on May 18, 1969, and the amendment to Part 31 became effective on July 17, 1969.

Byproduct Material in Gas and Aerosol Detectors—Parts 30 and 32

On April 18, 1969, amendments to Parts 30 and 32 were published, effective May 18, 1969, which provide an exemption for the use of byproduct material in gas and aerosol detectors designed to protect life or property from fires and airborne hazards, if the detectors are manufactured, processed, produced, imported, or transferred under a specific license issued by the AEC pursuant to § 32.26. The amendments also set forth requirements for issuance of the license to the manufacturer or importer.

Exemptions of Self-Luminous Products—Parts 30 and 32

On June 6, 1969, amendments to Parts 30 and 32 were published effective July 6, 1969, which establish a class exemption for self-luminous products containing tritium, krypton-85, and promethium-147 when such products have been manufactured, imported, or transferred pursuant to a specific license issued by the AEC authorizing distribution for use under the exemption, and establish requirements for the issuance of specific licenses authorizing manufacture, import, or transfer of self-luminous products containing such byproduct material for possession and use under the exemption.

Uranium Contained in Counterweights—Part 40

On September 5, 1969, amendments to Part 40 ("Licensing of Source Material") were published, effective upon publication, which revise the exemption of uranium contained in counterweights installed in aircraft, rockets or projectiles. The amendments revise the labeling requirements for such counterweights and the requirements for plating or other covering. The general license for export of counterweights also was amended to reflect the new labeling requirements.

Consideration of Ultimate Power Level—Part 50

On April 23, 1969, an amendment to Part 50 was published, effective May 23, 1969, which requires applicants for facility construction permits to include in the preliminary safety analysis report, an analysis and evaluation of the major systems and components of the facility which bear significantly on the acceptability of the site, assuming that the facility will be operated at the ultimate power level which is contemplated by the applicant. Submission of that information will permit the evaluation of all major systems and components at the construction permit stage, to the extent permitted by available information.

Protection of Special Nuclear Material in Transit—Part 73

On April 9, 1969, the Commission published a new regulation, Part 73, effective upon publication, imposing specific requirements for safeguarding licensed special nuclear material in transit. The regulation provides that special nuclear material in quantities of more than 5,000 grams of uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium, or any combination of these, shall be either transported under the continuous personal custody of an authorized individual or under signature service of a common or contract carrier. Requirements for records of shipments and reports of lost or unaccounted for shipments are also provided.

Financial Protection—Part 140

On January 17, 1969, amendments to Part 140 ("Financial Protection Requirements and Indemnity Agreements") were published, effective February 1, 1969, which increased to $82 million the amount of financial protection required for production and utilization facilities having a rated capacity of 100 electrical megawatts or more. The amendments reflect the increase in nuclear energy liability insurance available.

Transfer of Products Containing Exempt Material—Part 150

On April 16, 1969, an amendment to Part 150 ("Exemptions and Continued Regulatory Authority in Agreement States under Section 274") was published, effective May 16, 1969, which redefines the basis of continued AEC regulatory authority in Agreement States over the transfer by the manufacturer of products containing byproduct or source material whose subsequent possession, use, transfer, and disposal by all other persons are exempted from the AEC's licensing and regulatory requirements.

License Fees—Part 170

On September 27, 1969, an amendment to Part 170 ("Fees for Facilities and Materials Licenses Under the Atomic Energy Act of 1954, as amended") was published, effective upon publication, which provided that no license fees are payable for facilities licensed for possession only.

Miscellaneous Amendments—Parts 1, 2, 20, 30, 36, 40, 50, 55, 70, 71, 115, 140, 150, and 170

On December 11, 1969, amendments to Parts 1, 2, 20, 30, 36 ("Export and Import or Byproduct Material"), 40, 50, 55 ("Operators' Licenses"), 70 ("Special Nuclear Material"), 71 ("Packaging of Radioactive Material for Transport"), 115, 140, 150, and 170 were published, effective upon publication, pertaining to corrective and procedural matters and modifying certain sections of the regulations which provide for specific exemptions from regulatory requirements.

PROPOSED REGULATIONS AND AMENDMENTS

Safeguards and Physical Security Measures—Part 2

On April 25, 1969, proposed amendments of Part 2 were published for public comment which would provide a better means of protecting special nuclear materials safeguards information and information on the detailed physical security measures for licensed production and utilization facilities. Under the proposed amendments, correspondence between licensees or license applicants and the Commission regarding special nuclear materals safeguards and detailed physical security measures for licensed production and utilization facilities would be treated as exempt from public disclosure unless the Director of Regulation determines that its production or disclosure would not be contrary to the public interest and would not adversely affect the rights of any person.

Backfitting of Nuclear Facilities—Parts 2 and 50

On April 16, 1969, proposed amendments to Parts 2 and 50 were published for public comment, which would clarify the Commission's position with respect to requirements for additional safety features after the issuance of a construction permit. The proposed amendments would also define more precisely the significance of the issuance of a construction permit and eliminate the provisional operating license.

High Radiation Areas—Part 20

On September 25, 1969, proposed amendments to Part 20 were published for public comment which would provide additional methods of controlling access to high radiation areas. The proposed amendments would require that such controls be established in a manner which would not prevent exit from the area. Alternatives to these control methods could be submitted by the licensee for AEC approval.

Exempt Concentrations and Generally Licensed Items—Parts 30 and 31

On November 13, 1969, proposed amendments to Parts 30 and 31 were published for public comment which would add a specific listing for strontium-85 to the exempt concentrations in § 30.70 and revoke the general license in § 31.3(c) for a light meter containing strontium-90.

Exemption of Microwave Receiver Protector Tubes

On December 25, 1969, proposed amendments to Part 30 were published for public comment which would exempt from licensing requirements microwave receiver protector tubes containing not more than 150 millicuries of tritium.

Piezoelectric Ceramic Containing Source Material Exemption—Part 40

On December 10, 1969, a proposed amendment to Part 40 was published for public comment to provide an exemption for piezoelectric ceramic containing not more than 2 percent by weight source material.

Source Material Reports—Parts 40 and 150

On September 12, 1969, proposed amendments of Parts 40 and 150 ("Exemptions and Continued Regulatory Authority in Agreement States Under Section 274") were published for public comment which would require AEC and Agreement State licensees to submit to the Commission certain safeguards reports on source material. Licensees would be required to submit: (*a*) A report concerning each transfer, receipt, export, and import of 1,000 kgs or more of uranium or thorium; (*b*) a statement of their inventories of source material as of June 30 of each year; and (*c*) a report concerning any attempted theft or unlawful diversion of source material.

Quality Assurance Criteria for Nuclear Powerplants—Part 50

On April 17, 1969, proposed amendments to Part 50 were published for public comment, which would establish quality assurance requirements for the design, construction, and operation of structures, systems and components of nuclear powerplants that are important to safety.

Siting of Commercial Fuel Reprocessing Plants and Related Facilities—Part 50

On June 3, 1969, the Commission published a statement of proposed policy for public comment dealing with: (*a*) The location of commercial fuel reprocessing plants and (*b*) the question of ultimate disposal of high level radioactive fission product wastes generated at those plants.

Codes and Standards for Power Reactors—Parts 50 and 115

On November 25, 1969, proposed amendments to Parts 50 and 115 were published for public comment, which would require compliance with the requirements of specified industry codes by holders of construction permits for nuclear power reactors.

Power Reactor Facility Work Prior to Construction Permit Issuance—Parts 50 and 115

On February 19, 1969, proposed amendments to Parts 50 and 115 were published for public comment which would specify the conditions under which exemptions may be granted for the performance of certain construction work before a construction permit is issued.

Nuclear Material Status and Transfer Reports—Parts 70 and 150

On June 10, 1969, proposed amendments of Part 70 were published for public comment which would require AEC licensees to submit to the Commission material status reports on a new report Form AEC–742 concerning all special nuclear material received, produced, possessed, transferred, consumed, disposed of or lost, without regard to origin of the material or the authority under which the Commission may have distributed the material. In addition, the proposed amendments of Parts 70 and 150 would require AEC and Agreement State licensees to submit to the Commission nuclear material transfer reports on a new report Form AEC–741. Most of the information called for on Forms AEC–741 and AEC–742 is needed by the Commission to carry out its responsibilities for assuring that special nuclear material is adequately safeguarded in the interest of the common defense and security.

Physical Protection of Special Nuclear Material—Part 73

On June 11, 1969, proposed amendments of Part 73 were published for public comment which would prescribe requirements for the physical protection of special nuclear material in use and storage, including: (*a*) Use only in a protected area and under surveillance of an authorized individual; and (*b*) storage in a locked security container or locked building.

Recognition of Agreement State Licensees—Part 150

On December 20, 1969, the Commission published a proposed amendment to Part 150 for public comment which would (a) increase the time from 20 days in any period of 12 consecutive months to 180 days in any calendar year that an Agreement State specific licensee may possess or use radioactive material in non-Agreement States under the general license in Section 150.20; (b) require that persons operating under the general license must hold a specific license issued by the Agreement State where the licensee maintains an office for directing the licensed activity; and at which radiation safety records are normally maintained; and (c) modify the requirements for filing reports by such licensees of proposed activities in non-Agreement States.

Cufflinks of Depleted Uranium

On April 24, 1969, the Commission published a Notice of Denial of Petition for Rule Making to amend Part 40 to exempt cufflinks of depleted uranium from licensing requirements.

Self-Luminous Screws Containing Tritium

On June 6, 1969, the AEC published a notice of Denial of Petition for Rule Making to amend Part 30 to exempt from licensing requirements self-luminous screws containing not more than 5 millicuries of tritium per screw.

Automobile Lock Illuminators

On December 24, 1969, the AEC published a Notice of Denial of Petition for Rule Making to amend Part 30 to modify the present exemption for self-luminous lock illuminators, containing tritium or promethium-147, installed in automobile locks. The requested amendment would have made the illuminator an exempt item when it leaves the manufacturer's plant and prior to installation in a lock.

APPENDIX 6

INTERNATIONAL AGREEMENTS

Bilateral Agreements for Cooperation in the Civil Uses of Atomic Energy

Country	Scope	Effective date	Termination date
Argentina	Research and Power	July 25, 1969	July 24, 1999
Australia	do	May 28, 1957	May 27, 1997
Austria	Research	Jan. 25, 1960	Jan. 24, 1970
Brazil	do	Nov. 9, 1966	Aug. 2, 1975
Canada	Research and Power	July 21, 1955	July 13, 1980
China, Republic of	Research	July 18, 1955	July 17, 1974
Denmark	do	July 25, 1955	July 24, 1973
Greece	do	Aug. 4, 1955	Aug. 3, 1974
India	Power	Oct. 25, 1963	Oct. 24, 1993
Indonesia	Research	Sept. 21, 1960	Sept. 20, 1970
Iran	do	Apr. 27, 1959	Apr. 26, 1979
Ireland	do	July 9, 1958	July 8, 1978
Israel	do	July 12, 1955	Apr. 11, 1975
Italy	Research and Power	Apr. 15, 1958	Apr. 14, 1978
Japan	do	July 10, 1968	July 9, 1998
Korea	Research	Feb. 3, 1956	Feb. 2, 1976
Norway	Research and Power	June 8, 1967	June 7, 1997
Philippines	do	July 19, 1968	July 18, 1998
Portugal	Research	July 19, 1969	July 18, 1979
South Africa	Research and Power	Aug. 22, 1957	Aug. 21, 1977
Spain	do	Feb. 12, 1958	Feb. 11, 1988
Sweden	do	Sept. 15, 1966	Sept. 14, 1996
Switzerland	do	Aug. 8, 1966	Aug. 7, 1996
Thailand	Research	Mar. 13, 1956	Mar. 12, 1975
Turkey	do	June 10, 1955	June 9, 1971
United Kingdom	do	July 21, 1955	July 20, 1976
United Kingdom	Power	July 15, 1966	July 14, 1976
Venezuela	Research and Power	Feb. 9, 1960	Feb. 8, 1970
Vietnam	Research	July 1, 1959	June 30, 1974
Special Arrangement:			
U.S.-U.S.S.R	Memorandum on Cooperation on the Peaceful Uses of Atomic Energy.	July 29, 1968	Dec. 31, 1969
U.S.-Romania	do	Jan. 1, 1969	Dec. 31, 1970

Agreements for Cooperation with International Organizations

Organization	Scope	Effective date	Termination date
European Atomic Energy Community (Euratom).	Joint Nuclear Power Program	Feb. 18, 1959	Dec. 31, 1985
Euratom	Additional Agreement to Joint Nuclear Power Program.	July 25, 1960	Dec. 31, 1995
International Atomic Energy Agency (IAEA).	Supply of materials, etc	Aug. 7, 1959	Aug. 6, 1979

Trilateral Safeguards Agreements

	Scope	Effective date
U.S./IAEA/Argentina	Trilateral for application of IAEA safeguards to U.S.-supplied materials.	July 25, 1969
U.S./IAEA/Australia	do	Sept. 26, 1966
U.S./IAEA/Austria	do	Dec. 13, 1965
U.S./IAEA/Brazil	do	Oct. 31, 1968
U.S./IAEA Republic of China	do	Oct. 29, 1965
U.S./IAEA/Denmark	do	Feb. 29, 1968
U.S./IAEA/Greece	do	Jan. 13, 1966
U.S./IAEA/Indonesia	do	Dec. 6, 1967
U.S./IAEA/Israel	do	June 15, 1966
U.S./IAEA/Iran	do	Aug. 20, 1969
U.S./IAEA/Japan	do	July 10, 1968
U.S./IAEA/Korea	do	Jan. 5, 1968
U.S./IAEA/Philippines	do	July 19, 1968
U.S./IAEA/Portugal	do	Dec. 15, 1965
U.S./IAEA/South Africa	do	July 26, 1967
U.S./IAEA/Spain	do	Dec. 9, 1966
U.S./IAEA/Thailand	do	Sept. 10, 1965
U.S./IAEA/Turkey	do	June 5, 1969
U.S./IAEA/Venezuela	do	Mar. 27, 1968
U.S./IAEA/Vietnam	do	Oct. 25, 1965

Agreements for Cooperation for Mutual Defense Purposes [1]

	Effective date
NATO	Mar. 12, 1965
Australia	Aug. 14, 1957
Belgium	Sept. 5, 1962
Canada	July 27, 1959
France (Land-Based Prototype Fuel Supply Agreement)	July 20, 1959
France	Oct. 9, 1961
Germany, Federal Republic of	July 27, 1959
Greece	Aug. 11, 1959
Italy	May 24, 1961
Netherlands	July 27, 1959
Turkey	July 27, 1959
United Kingdom	Aug. 4, 1958

[1] Except for the Agreement with France of July 20, 1959, all these Agreements provide for exchange of classified information as provided for in Section 144b of the Atomic Energy Act.

APPENDIX 7

TECHNICAL INFORMATION

AEC-SPONSORED BOOKS, MONOGRAPHS, AND PROCEEDINGS PUBLISHED IN 1969

Title	Authors and editors	Publisher and price [1]
Books		
Metal Hydrides	W. M. Mueller, J. P. Blackledge, G. G. Libowitz.	Academic Press, New York, $29.50.
The Optics of Dipole Magnets	J. J. Livingood	Academic Press, New York, $13.50.
Stress Rupture Parameters: Origin, Calculation and Use.	J. B. Conway	Gordon & Breach, New York, L/R-$15.50, P/S-$7.75.
Applied Radiation Protection and Control.	J. J. Fitzgerald	Gordon & Breach, New York, Vol. I-L/R-$27.50, P/S-$13.75; Vol. II-L/R-$23.00, P/S-$11.50.
Antennas and Waves: A Modern Approach.	R. W. P. King, C. W. Harrison, Jr.	The M.I.T. Press, Cambridge, Mass., $15.00.
Monographs (Cooperating Society)		
Irradiation Effects in Nuclear Fuels (Am. Nu. Soc.).	J. A. L. Robertson	Gordon & Breach, New York, L/R-$15.50, P/S-$7.75.
Pulse Radiolysis (Am. Chem. Soc.)	M. S. Matheson, L. M. Dorfman	The M.I.T. Press, Cambridge, Mass., $11.75.
Water Coolant Technology of Power Reactors (Am. Nuc. Soc.).	P. Cohen	Gordon & Breach, New York, L/R-$21.50, P/S-$10.75.
Properties of Refractory Metals (Am. Soc. for Metals).	W. D. Wilkinson	Gordon & Breach, New York, L/R-$17.75, P/S-$8.90.
Critical Review Series		
Plume Rise	G. A. Briggs	$3.00.[2]
Atmospheric Transport Processes, Part I, Energy Transfer and Transformations.	E. R. Reiter	$3.00.[2]
Sources of Tritium and Its Behavior Upon Release to the Environment.	D. G. Jacobs	$3.00.[2]
AEC Symposium Series		
Abundant Nuclear Energy	W. W. Grigorieff	$3.00.[2]
Myeloproliferative Disorders of Animals and Man.	W. J. Clarke	$3.00.[2]
Fast Burst Reactors	R. L. Long, P. D. O'Brien	$3.00.[2]
Radiation Biology of the Fetal and Juvenile Mammal.	M. I. Sikov	$3.00.[2]
Biological Implications of the Nuclear Age.	B. Shore, F. Hatch	$3.00.[2]

[1] The "L/R" represents price for Library and Reference Edition, "P/S", the Professional and Student Edition.

[2] Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.

NEW BOOKLETS IN AEC'S "UNDERSTANDING THE ATOM" SERIES

A complete list of all 53 "Understanding the Atom" booklets published can be obtained from U.S. AEC-Technical Information, Post Office Box 62, Oak Ridge, Tenn. 37830. Single copies of booklets (limit: 3 titles per request) are available free of charge. During 1969, these three booklets were added: "The Elusive Neutrino," "Nuclear Power and the Environment," and "Books on Atomic Energy for Adults and Children."

The following "Understanding the Atom" booklets are available in Braille from the American Printing House for the Blind, Louisville, Ky.: Cryogenics ($2.25); Nuclear Power and Merchant Shipping ($1.65); Lasers ($2.25); Your Body and Radiation ($3.15); Careers in Atomic Energy ($.95); Nuclear Terms, A Brief Glossary ($4.20); and Animals in Atomic Research ($2.40).

STATE ORGANIZATIONS COOPERATING IN "THIS ATOMIC WORLD" HIGH SCHOOL LECTURE-DEMONSTRATION PROGRAM

State	Participating Organization	First year in program
Alabama	University of Alabama at Birmingham	1969
Arizona	Arizona Atomic Energy Commission	1969
Arkansas	University of Arkansas	1969
Florida	University of South Florida	1968
Illinois	Northern Illinois University	1969
Kentucky	Morehead State University	1968
Louisiana	Louisiana State University	1968
New Hampshire	Plymouth State College	1969
New York (2 units)	Empire State Atomic Development Associates	1967
North Carolina	North Carolina State University	1967
Oklahoma	Oklahoma State University	1968
Oregon	University of Oregon	1968
Pennsylvania-Eastern Ohio	Geneva College	1969
Texas	Texas A&M University	1966
Virginia	Virginia Polytechnic Institute	1969
Wisconsin	University of Wisconsin	1968

APPENDIX 8

AEC FINANCIAL SUMMARY FOR FISCAL YEAR 1969*

The Atomic Energy Commission is an independent agency responsible to the President and Congress. It was established by the Atomic Energy Act of 1946 to assume the responsibility for the development, use and control of atomic energy and for the production of nuclear weapons. In 1954 the functions and responsibilities of the AEC were expanded to provide for greater emphasis on developing and promoting peaceful uses of atomic energy. The Private Ownership of Special Nuclear Materials Act of 1964 authorized the AEC to offer a service of enriching privately owned uranium in uranium-235 under long-term contracts beginning January 1, 1969. The AEC received revenue of $30 million from this service through June 30, 1969.

The date for permitting acquisition of enriched uranium by "in situ" toll enrichment was advanced to April 1, 1969, from January 1, 1971. "In situ" toll enrichment permits the lessee to acquire ownership of leased material upon furnishing, as payment, required amounts of uranium feed and dollars. The advancement of the beginning date for "in situ" tolling is consistent with the AEC policy that industry obtain enriched uranium through toll enrichment of uranium procured from private sources.

The AEC's operating expenses are approximately $2.6 billion per year. Most of the work involved in achieving AEC goals is performed under contract with commercial firms and educational and other nonprofit organizations in government-owned facilities. These AEC contractors have approximately 111,000 employees engaged in operations and 14,000 in construction work. AEC has 7,467 employees including 420 temporary and part-time workers.

Those responsible for management require knowledge of the costs incurred within the AEC complex. The AEC accounting system must not only supply such knowledge but must comply with the requirements of Federal Government fund accounting. The system developed to meet both these requirements has the approval of the General Accounting Office. Like industrial accounting systems, it follows accrual and cost accounting principles, including the recording of depreciation. The accounting records maintained by major contractors for their AEC activities are an integral part of the Commission's system of financial management. This financial report is a consolidation of information obtained from financial reports made to the AEC by its contractors and information obtained from the AEC records.

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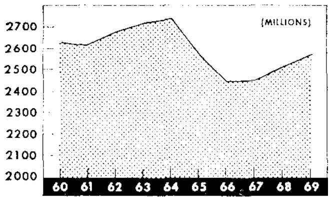
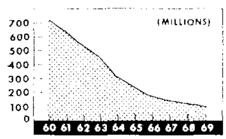
*Material in this appendix is extracted from the "U.S. Atomic Energy Commission—1969 Financial Report," available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, price 60 cents.

SUMMARY OF NET OPERATING COSTS

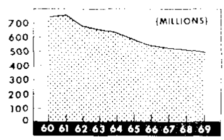
1969
(Millions)



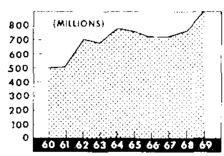
TOTAL OPERATING COSTS.......... $2566 100%



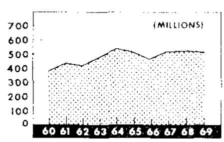
RAW MATERIALS.......... $101 4%



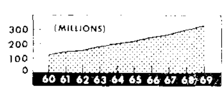
PRODUCTION OF NUCLEAR MATERIALS..... $495 19%



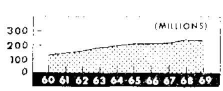
WEAPONS DEVELOPMENT AND FABRICATION...... $898 35%



REACTOR DEVELOPMENT.... $508 20%



PHYSICAL RESEARCH...... $332 13%



OTHER PROGRAMS....... $232 9%

STATEMENT OF OPERATIONS

	Fiscal Year 1969 (in thousands)	Fiscal Year 1968 (in thousands)
Production		
Raw materials	$101,032	$125,377
Production of nuclear materials	495,244	506,911
Weapons development and fabrication	897,802	783,581
	1,494,078	1,415,869
Research and development		
Development of nuclear reactors	508,442	548,546
Physical research	331,638	310,140
Biology and medicine research	99,105	98,601
Plowshare	14,963	20,029
Isotope development	7,629	8,370
	961,777	985,686
Community operations		
Expenses	725	1,952
Revenues	(381)	(1,032)
	344	920
Sales of materials and services		
Cost	92,207	61,093
Revenue	(103,989)	(65,926)
	(11,782)	(4,833)
Education and training	10,259	9,766
AEC administrative expenses	108,204	96,984
Security investigations	7,178	6,848
Other expenses	13,377	13,233
Other income	(17,186)	(17,620)
Net cost of operations*	2,566,249	2,506,853
Special items		
Adjustments to costs of prior years—net	11,761	75,337
Transfers to inventories—net	(200,907)	(266,295)
Net cost of operation—after special items*	2,377,103	2,315,895

*Includes depreciation of $381 million in 1969 and $361 million in 1968.

BALANCE SHEET

ASSETS*

	June 30, 1969 (*in thousands*)	June 30, 1968 (*in thousands*)
Cash		
Funds in U.S. Treasury	$1,665,208	$1,499,723
Cash on hand and with contractors	12,391	7,006
Transfers from other agencies	1,116	1,437
	1,678,715	1,508,166
Accounts receivable		
Federal Agencies	36,346	50,714
Other	39,647	61,314
	75,993	112,028
Inventories		
Source and nuclear materials leased and at research installations	1,226,395	1,058,573
Special reactor materials	106,694	101,786
Stores	87,089	89,795
Isotopes	37,160	39,080
Other special materials	13,997	14,457
	1,471,335	1,303,691

LIABILITIES AND AEC EQUITY*

	June 30, 1969 (*in thousands*)	June 30, 1968 (*in thousands*)
Liabilities		
Accounts payable and accrued expenses	$323,140	$313,338
Advances from other agencies	1,116	1,437
Funds held for others	9,747	15,026
Accrued annual leave of AEC employees	11,302	10,311
Deferred credits	84,254	15,043
Total liabilities	429,559	355,155
AEC equity, July 1	8,190,173	8,065,706
Additions		
Funds appropriated—net	2,615,844	2,509,125
Non-reimbursable transfers from other agencies	4,783	3,598
	2,620,627	2,512,723
Deductions		
Net cost of operations—after special items	2,377,103	2,315,895
Non-reimbursable transfers to other agencies	14,445	71,406
Funds returned to U.S. Treasury		955
	2,391,548	2,388,256

Plant		
Completed plant and equipment	9, 012, 196	8, 826, 896
Less—Accumulated depreciation	3, 905, 230	3, 595, 128
	5, 106, 966	5, 231, 768
Construction work in progress	441, 685	299, 948
	5, 548, 651	5, 531, 716
Other	74, 117	89, 727
Total assets	8, 848, 811	8, 545, 328

AEC equity, June 30	8, 419, 252	8, 190, 173
Total liabilities and AEC equity	8, 848, 811	8, 545, 328

*The notes below 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. 2,263,954 troy ounces of silver loaned to the AEC by the Treasurer of the United States for use as electrical conductors in plants. Of this amount, 260,300 troy ounces have been lost in usage and are, therefore, not returnable. Based on Treasury selling price at June 30, 1969, the value of the silver on loan was $3,531,768. The value of silver lost and the cost of recovering and processing that on hand and returning it to the Treasury is estimated at $349,000.
   c. Plant and equipment on loan from other Federal agencies at June 30, 1969, amounting to $36,450,000.
   d. Contested claims against others of $1,336,000.
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, 1969, the estimated liabilities would have amounted to $446,377,000.
   b. Contingent liabilities for claims against the AEC of $45,769,000.
   c. Commitments for an estimated 5,920 tons of U_3O_8 at an estimated cost of $69,619,200. All contracts for procurement of U_3O_8 will expire December 31, 1970.
   d. Commitments under Section 56 of the Atomic Energy Act of 1954, as amended, for acquisition of an undetermined amount of plutonium and uranium enriched in the isotope 233. The liability for acquisition of plutonium will cease to exist December 31, 1970.
   e. Outstanding contracts, purchase orders and other commitments of $1,392,400,000.

COSTS INCURRED BY AEC RESEARCH LABORATORIES

A major portion of AEC research and development is conducted in Government-owned laboratories operated by educational institutions, industrial concerns and non-profit organizations under AEC contracts. On June 30, 1969, the AEC's investment in research facilities totaled $3.1 billion. Of this amount, $2.2 billion was invested in the major Government-owned laboratories. These facilities include research reactors, particle accelerators, general laboratory buildings, equipment, and research devices.

The 11 laboratories listed are the principal AEC-owned research centers. 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.

The basic research carried out in the AEC laboratories, while motivated and justified on the basis of its relevance to atomic energy, is not limited to atomic energy purposes in its eventual usefulness and application. The basic knowledge arising from AEC programs continues to make contributions to non-AEC programs of great national significance.

Within present authorities, a portion of AEC laboratory capabilities is being used on problems of other agencies, giving due regard to the AEC misson and the interface it has with the interests of other agencies.

Laboratories	Cost of completed plant June 30, 1969	Operating costs fiscal year 1969	Operating costs fiscal year 1968
	[In thousands]		
Ames Research Laboratory	$24,366	$9,023	$9,363
Argonne National Laboratory [1]	365,381	120,990	102,030
Bettis Atomic Power Laboratory [1]	143,742	75,428	73,627
Brookhaven National Laboratory	248,994	62,163	63,103
Knolls Atomic Power Laboratory [1]	150,058	64,666	65,376
Lawrence Radiation Laboratory [2]	349,481	177,975	184,031
Los Alamos Scientific Laboratory [2]	278,066	109,301	104,620
Oak Ridge National Laboratory	344,485	90,347	90,350
Pacific Northwest Laboratory	108,624	56,194	50,951
Savannah River Laboratory	78,675	12,689	13,567
Stanford Linear Accelerator Center	142,474	30,556	28,130

[1] Includes facilities at NRTS, Idaho.
[2] Includes facilities in Nevada.

AEC COSTS BY GEOGRAPHICAL LOCATIONS

This table shows the costs incurred by the AEC in fiscal year 1969. The allocations of costs are made in accordance with the physical location of contractors and AEC offices but do not necessarily represent funds spent in those locations.

Location	Operations*	Plant and capital equipment	Total
		[In thousands]	
Alabama	$65	$10	$75
Alaska	48,580		48,580
Arizona	362		362
Arkansas	195		195
California	290,033	49,805	339,838
Colorado	52,279	37,806	90,085
Connecticut	6,650	333	6,983
Delaware	65		65
District of Columbia	14,937	1,074	16,011
Florida	17,199	3,675	20,874
Georgia	1,271	27	1,298

See footnote at end of table.

Location	Operations*	Plant and capital equipment	Total
	[In thousands]		
Hawaii (including Pacific Test Area)	$3,534	$ 3	$3,537
Idaho	71,147	23,986	95,133
Illinois	96,150	36,564	132,714
Indiana	2,841	427	3,268
Iowa	16,893	3,889	20,782
Kansas	712	308	1,020
Kentucky	59,479	1,139	60,618
Louisiana	321		321
Maine	189		189
Maryland	62,480	2,063	64,543
Massachusetts	25,444	6,792	32,236
Michigan	5,953	376	6,329
Minnesota	4,117	167	4,284
Mississippi	52		52
Missouri	80,796	7,068	87,864
Montana	91		91
Nebraska	795	19	814
Nevada	191,960	10,597	202,557
New Hampshire	378	2	380
New Jersey	17,743	3,166	20,909
New Mexico	330,981	43,847	374,828
New York	131,929	34,595	166,524
North Carolina	2,120	695	2,815
North Dakota	60		60
Ohio	93,159	10,917	104,076
Oklahoma	404		404
Oregon	1,239	17	1,256
Pennsylvania	93,558	6,421	99,979
Puerto Rico	2,780	1,078	3,858
Rhode Island	590		590
South Carolina	87,299	14,829	102,128
South Dakota	264		264
Tennessee	214,885	88,589	303,474
Texas	17,503	5,837	23,340
Utah	7,556	26	7,582
Vermont	75		75
Virginia	2,327	62	2,389
Washington	136,491	16,500	152,991
West Virginia	119		119
Wisconsin	4,485	135	4,620
Wyoming	22,331		22,331
Foreign Countries	4,578	137	4,715
Total	2,227,444	412,981	2,640,425

*Excludes depreciation.

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AEC COSTS BY COLLEGES AND UNIVERSITIES

In addition to the activities of the AEC laboratories (shown in previous table), some of which are operated for the AEC by universities or associations of universities, the AEC had other contracts with 223 colleges or universities for atomic energy work. This table shows that the cost of this work totaled $137 million in fiscal year 1969 and identifies each university where costs in excess of $500,000 were incurred.

COLLEGES AND UNIVERSITIES	Fiscal year 1969	
	Rank by dollar volume of costs incurred	Total costs* (in thousands)
Brown University	42	$ 590
California Institute of Technology	12	3,484
California, University of	4	7,106
California, University of, at Los Angeles	8	4,697
Carnegie-Mellon University	19	1,906
Case Western Reserve University	27	1,147
Chicago, University of	5	5,130
Colorado, University of	34	936
Columbia University	7	4,886
Cornell University	20	1,822
Duke University	26	1,484
Florida State University	29	1,058
Georgia Institute of Technology	45	520
Georgia, University of	50	502
Harvard University	3	7,333
Hawaii, University of	47	517
Illinois, University of	9	4,492
Johns Hopkins University	32	1,016
Kansas State University	43	558
Maryland, University of	11	3,744
Massachusetts Institute of Technology	2	9,042
Michigan State University	18	2,221
Michigan, University of	14	2,995
Minnesota, University of	22	1,810
New York State, University of	31	1,035
New York University	23	1,766
North Carolina State University	46	518
North Carolina, University of	44	549
Notre Dame, University of	25	1,596
Ohio State University	37	741
Oregon State University	40	619
Oregon, University of	49	512
Pennsylvania State University	41	608
Pennsylvania, University of	16	2,552
Pittsburgh, University of	48	513
Princeton University	1	17,517
Puerto Rico, University of	17	2,424
Purdue University	21	1,813
Rensselaer Polytechnic Institute	28	1,110
Rice University	35	874
Rochester, University of	6	5,122
Southern California, University of	39	676
Stanford University	38	691
Tennessee, University of	24	1,611
Texas A&M University	33	999
Texas, University of	36	791
Utah, University of	30	1,036
Washington, University of	15	2,677
Wisconsin, University of	13	3,325
Yale University	10	3,762
Other (173 colleges and universities)		12,582
Total		137,015

*These costs exclude depreciation and include construction and capital equipment.

AEC COSTS BY PRIME INDUSTRIAL CONTRACTORS

Private industrial organizations working under contract with the AEC perform most of the production and much of the research and development work accomplished by the AEC. In fiscal year 1969, the AEC's prime industrial contractors accomplished work amounting to $1,735 million. This table lists the industrial *supply, production,* and *research and development contractors who incurred costs exceeding $5 million.* Except for depreciation, costs for the operation of laboratories are included in the costs of related contractors.

Industrial organizations	Fiscal year 1969	
	Rank by dollar volume of costs incurred	Total costs* (in thousands)
Aerojet-General Corp	17	$25,930
Anaconda Co	27	9,479
Atlantic Richfield Hanford Co	14	31,588
Atlas Corp	32	6,003
Atomics Int'l Div., North American Rockwell Corp	20	23,223
Bendix Corp	6	85,021
Douglas United Nuclear, Inc	10	44,822
Dow Chemical Co	11	42,813
EG&G, Inc	12	41,217
E. I. du Pont de Nemours & Co	4	99,085
Gulf General Atomic, Inc	25	14,620
General Electric Co	5	95,098
Goodyear Atomic Corp	13	35,327
Holmes & Narver, Inc	7	77,188
Idaho Nuclear Corp	9	48,438
Isotopes, Inc	30	6,864
ITT/Federal Support Services	31	6,293
Kerr-McGee Corp	21	20,867
Mason & Hanger-Silas Mason Co	19	24,100
Monsanto Research Corp	15	30,446
National Lead Co	22	20,623
Pan American World Airways, Inc	26	10,290
Reynolds Electrical and Engineering Co., Inc	3	106,519
Rust Engineering Co	16	28,276
Sandia Corp	2	214,290
Swinerton & Walberg Co	18	24,962
Union Carbide Corp	1	317,384
United Nuclear Corp	23	15,885
United Nuclear Homestake Partners	24	14,943
Utah Construction & Mining Co	29	7,002
Western Nuclear, Inc	28	7,906
Westinghouse Electric Corp	8	75,923
Other (506 industrial organizations)		123,021
Total		1,735,446

*These costs exclude depreciation and include construction and capital equipment.

AEC PLANT AND EQUIPMENT BY LOCATION

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
CALIFORNIA				
Atomics International Div., North American Rockwell Corp., Canoga Park and Santa Susana Reactor and Research Facilities	$49.9	$2.2	$11.6	$63.7
California Institute of Technology, Pasadena Research Facilities	1.7	1.9	.1	3.7
University of California, Lawrence Radiation Laboratory				
Berkeley	121.4	2.9	11.4	135.7
Livermore	218.2	19.7	26.1	264.0
Total Lawrence Radiation Laboratory	339.6	22.6	37.5	399.7
University of California, Davis Bio-Med Research Facilities	5.3	.2	.3	5.8
University of California, Los Angeles Medical Research Facilities	2.2		.7	2.9
EG&G, Inc., Santa Barbara Test Facilities	1.9		.7	2.6
EG&G, Inc., San Ramon Test Facilities	.6		1.0	1.6
Sandia Corp., Livermore Research Facilities	30.4	1.1	5.8	37.3
Stanford University, Palo Alto Linear Accelerator & Equipment	142.5	3.9	7.5	153.9
Total California	574.1	31.9	65.2	671.2
COLORADO				
University of Colorado, Boulder	1.6		.2	1.8
Dow Chemical Co., Rocky Flats	129.2	48.1	91.3	268.6
Lucius Pitkin, Inc., Grand Junction Uranium Handling, Sampling and General Facilities	4.3	.4	.3	5.0
Total Colorado	135.1	48.5	91.8	275.4
CONNECTICUT				
Combustion Engineering, Inc., Windsor Submarine Reactor Facilities	15.2			15.2
Yale University, New Haven Linear Accelerator	10.0		.4	10.4
Total Connecticut	25.2		.4	25.6
FLORIDA				
General Electric Co., Clearwater Pinellas Plant	22.7	5.3	4.1	32.1

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete	Total
IDAHO				
National Reactor Testing Station, Idaho Falls				
Argonne National Laboratory				
Reactor Facilities	$46.3	$2.8	$15.9	$65.0
General Electric Co.				
Knolls Atomic Power Laboratory	25.5		.2	25.7
Idaho Nuclear Corp.				
Advanced Test Reactor	42.9	6.5	.9	50.3
Auxiliary Reactor Area	5.8	.1	.2	6.1
Chemical Processing Plant	64.1	.8	3.4	68.3
Engineering Test Reactor	14.6		.5	15.1
General Facilities	68.5	1.0	4.3	73.8
Materials Test Reactor	15.1	.2	.1	15.4
Nuclear Safety Testing Engineering	13.7	12.2	16.1	42.0
Power Burst Facility	.3	9.7	6.0	16.0
Special Power Excursion Reactor Test	9.4		.2	9.6
Test Reactor Area	23.8	.4	.2	24.4
Total Idaho Nuclear Corp	258.2	30.9	31.9	321.0
Westinghouse Electric Corp.				
Large Ship Reactor	35.8	.1		35.9
Submarine Thermal Reactor	17.3			17.3
Other Research Facilities	19.3	1.2	9.6	30.1
Total Westinghouse Electric Corp	72.4	1.3	9.6	83.3
Total Idaho	402.4	35.0	57.6	495.0
ILLINOIS				
University of Chicago, Argonne				
Argonne National Laboratory	319.1	32.3	26.4	377.8
University of Chicago, Chicago				
Argonne Cancer Research Hospital	6.5	.4	.4	7.3
Research Equipment	1.8		.2	2.0
University of Illinois, Urbana				
Research Facilities	.7		.4	1.1
Universities Research Assn., Batavia				
National Accelerator Laboratory		16.4	233.6	250.0
Land and Other Research Facilities	21.9	.1	4.3	26.3
Total National Accelerator Lab	21.9	16.5	237.9	276.3
Total Illinois	350.0	49.2	265.3	664.5
INDIANA				
University of Notre Dame, Notre Dame				
Radiation Laboratory	3.0	.2	.3	3.5
IOWA				
Ames Research Laboratory, Ames				
Research Facilities	19.6	.5	2.4	22.5
Research Reactor	4.7			4.7
Mason and Hanger, Burlington				
AEC Plant	41.5	2.6	8.5	52.6
Total Iowa	65.8	3.1	10.9	79.8

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
KENTUCKY				
Union Carbide Corp., Paducah				
Feed Materials Plant	$31.4		$0.9	$32.3
Gaseous Diffusion Plant	755.6	$0.7	3.0	759.3
Total Kentucky	787.0	.7	3.9	791.6
MARYLAND				
AEC Headquarters, Germantown	23.0		2.7	25.7
University of Maryland, College Park				
Accelerator	.6	3.8	.2	4.6
Total Maryland	23.6	3.8	2.9	30.3
MASSACHUSETTS				
EG&G, Inc., Boston				
Test Facilities	6.0	.2	3.9	10.1
Harvard University, Cambridge				
Cambridge Accelerator	23.9	1.2	1.7	26.8
Massachusetts Institute of Technology, Cambridge				
Research Facilities	8.7	3.9	2.2	14.8
Total Massachusetts	38.6	5.3	7.8	51.7
MICHIGAN				
University of Michigan, Ann Arbor				
Research Facilities	2.2		.5	2.7
Michigan State University, East Lansing				
Research Facilities	1.5		.3	1.8
Total Michigan	3.7		.8	4.5
MINNESOTA				
University of Minnesota, Minneapolis				
Linear Accelerator	5.8	.1	.1	6.0
Rural Cooperative Power Assn., Elk River				
Elk River Reactor	10.7		1.3	12.0
Total Minnesota	16.5	.1	1.4	18.0
MISSOURI				
The Bendix Corporation, Kansas City	75.7	8.3	40.9	124.9
NEVADA				
Jackass Flats:				
Nuclear Rocket Development Station—Project Rover:				
University of California, Los Alamos Scientific Laboratory	16.1		.6	16.7
Pan American World Airways, Inc	64.5	2.0	3.5	70.0
Westinghouse Electric Corp	2.4	.2		2.6
Other Research Facilities	2.8			2.8
Total Jackass Flats	85.8	2.2	4.1	92.1

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
NEVADA				
Mercury:				
EG&G, Inc.				
Test Facilities	$19.0	$0.3	$4.8	$24.1
Lawrence Radiation Laboratory				
Laboratory Facilities	9.9	.2	.1	10.2
Reynolds Electrical & Engineering Co.				
Nevada Test Site	137.9	1.6	20.4	159.9
Total Mercury	166.8	2.1	25.3	194.2
Sandia Corp., Tonopah				
Research Facilities	13.3	.1	1.0	14.4
Total Nevada	265.9	4.4	30.4	300.7
NEW JERSEY				
Atomic Energy Commission, New Brunswick				
New Brunswick Laboratory	2.9	.5	1.2	4.6
Princeton University, Princeton				
Model C Stellarator Facilities	25.6	.2	.3	26.1
Princeton-Pennsylvania Accelerator	37.9	2.0	2.3	42.2
Total New Jersey	66.4	2.7	3.8	72.9
NEW MEXICO				
Albuquerque:				
EG&G, Inc.				
Test Facilities	1.9			1.9
Lovelace Foundation Laboratory	4.9	.1	.5	5.5
Sandia Corp.				
Sandia Laboratory	203.1	5.6	35.9	244.6
Total Albuquerque	209.9	5.7	36.4	252.0
Los Alamos:				
University of California				
Los Alamos Scientific Laboratory	262.0	14.3	93.5	369.8
The Zia Co.				
General Maintenance Facilities	58.6		.4	59.0
Total Los Alamos	320.6	14.3	93.9	428.8
Total New Mexico	530.5	20.0	130.3	680.8
NEW YORK				
New York City:				
Atomic Energy Commission				
Health and Safety Laboratory	2.6		.2	2.8
Columbia University				
Accelerator and Research Facilities	5.1		.6	5.7
New York University				
Computing and Other Research Facilities	3.8		.5	4.3
Total New York City	11.5		1.3	12.8
Associated Universities, Inc., Upton				
Brookhaven National Laboratory	249.0	37.0	38.8	324.8

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions) Completed	Construction work in progress	Estimated cost to complete [1]	Total
NEW YORK				
General Electric Co., Schenectady and West Milton				
Knolls Atomic Power Laboratory	$124.6	$6.4	$17.7	$148.7
Nuclear Materials and Equipment Corp., Niagara Falls				
Boron Plant	7.2	.1	.2	7.5
Rensselaer Polytechnic Institute, Troy				
Accelerator Facility	3.1		.2	3.3
University of Rochester, Rochester				
Medical Laboratory and 130″ Cyclotron	6.9		.5	7.4
Total New York	402.3	43.5	58.7	504.5
NORTH CAROLINA				
Duke University, Durham				
Accelerator and Research Facilities	1.0	2.4	.1	3.5
OHIO				
Battelle Memorial Institute, Columbus				
Research Facilities	.9			.9
General Electric Co., Cincinnati				
Research Facilities	10.9	.2	.3	11.4
Goodyear Atomic Corp., Portsmouth				
Gaseous Diffusion Plant	767.2	1.1	4.1	772.4
Monsanto Chemical Co., Miamisburg				
Mound Laboratory	61.9	14.1	19.4	95.4
National Lead Co., Fernald				
Feed Materials Plant	117.3	.4	1.6	119.3
Ohio University, Athens				
Research Facilities		.3	.7	1.0
Reactive Metals, Inc., Ashtabula				
Feed Materials Facility	1.8		.1	1.9
Total Ohio	960.0	16.1	26.2	1,002.3
PENNSYLVANIA				
Carnegie-Mellon University, Pittsburgh				
Accelerator and Research Facilities	1.2			1.2
Duquesne Light Co., Shippingport				
Shippingport Atomic Power Station	63.4	.5	1.6	65.5
Westinghouse Electric Corp., Large				
Astro Nuclear Laboratory	10.0	.5	2.0	12.5
Westinghouse Electric Corp., Pittsburgh				
Bettis Atomic Power Laboratory	71.2	4.7	21.4	97.3
Total Pennsylvania	145.8	5.7	25.0	176.5
SOUTH CAROLINA				
E. I. Du Pont de Nemours and Co., Inc., Aiken				
Savannah River Plant				
Feed Materials Production Facility	32.5	1.2	1.8	35.5
General Facilities	167.2	4.0	8.6	179.8
Heavy Water Production Facilities	162.8			162.8
Laboratory	78.7	1.9	4.7	85.3
Production Reactor and Separation Facilities	867.3	10.7	16.3	894.3
Total South Carolina	1,308.5	17.8	31.4	1,357.7

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
TENNESSEE				
Oak Ridge:				
Oak Ridge Associated Universities				
Research Laboratory	$6.2	$0.1	$0.5	$6.8
Rust Engineering Co.				
Service Facilities	10.4	.4		10.8
University of Tennessee				
Agriculture Research Laboratory and Farm	3.8		.4	4.2
Union Carbide Corp.				
Gaseous Diffusion Plant	831.5	2.6	12.6	846.7
Oak Ridge National Laboratory	344.5	16.6	21.3	382.4
Y-12 Plant	391.7	86.1	103.2	581.0
Total Tennessee	1,588.1	105.8	138.0	1,831.9
TEXAS				
Mason and Hanger, Amarillo				
Pantex Plant	58.5	3.6	13.6	75.7
Rice University, Houston				
Research Facility	1.9		.1	2.0
Texas A&M University, College Station				
Research Facilities	.1	3.0	.3	3.4
Total Texas	60.5	6.6	14.0	81.1
UTAH				
University of Utah, Salt Lake City	1.3		.1	1.4
WASHINGTON				
Richland:				
Battelle Memorial Institute				
Pacific Northwest Laboratory	108.6	7.1	110.1	225.8
Computer Sciences Corp.				
General Facilities	3.8	.1		3.9
Douglas United Nuclear, Inc.				
Feed Materials Production Facilities	24.6		1.0	25.6
General Facilities	16.5		2.5	19.0
Production Reactor Facilities	582.0	2.2	4.5	588.7
Total Douglas United Nuclear, Inc	623.1	2.2	8.0	633.3
Atlantic Richfield, Hanford Co.				
General Facilities	2.8			2.8
Separation Facilities	277.1	3.3	20.5	300.9
Total Atlantic Richfield Corp	279.9	3.3	20.5	303.7
ITT/Federal Support Services, Inc.				
General Facilities	68.9	.7	1.7	71.3
J. A. Jones Construction Co.				
General Facilities	2.5			2.5
Total Washington	1,086.8	13.4	140.3	1,240.5

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
WEST VIRGINIA				
International Nickel Co., Huntington Pilot Plant	$4.7			$4.7
WISCONSIN				
Dairyland Power Cooperative, Genoa LaCrosse Boiling Water Reactor	.2	$10.2	$0.6	11.0
University of Wisconsin, Madison Research Facilities	1.5		.2	1.7
Total Wisconsin	1.7	10.2	.8	12.7
PUERTO RICO				
University of Puerto Rico, Mayaguez and Rio Piedras Puerto Rico Nuclear Center	7.3	.8	1.9	10.0
Puerto Rico Water Resources Authority, Punta Higuera Boiling Nuclear Super Heat Reactor	*13.3	.1		13.4
Total Puerto Rico	20.6	.9	1.9	23.4
JAPAN				
National Academy of Sciences, Hiroshima Research Facilities	3.1		.3	3.4
All Other	41.6	.8	35.1	77.5
TOTAL	9,012.2	441.7	1,189.7	10,643.6

[1] Includes plant and capital equipment authorized in Public Law 91-44, approved July 11, 1969.
*Deactivated.

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