UNITED STATES ATOMIC ENERGY COMMISSION

Annual Report to Congress

OF THE

ATOMIC ENERGY COMMISSION

FOR

1970

January 1971

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

LETTER OF SUBMITTAL

WASHINGTON, D.C.,
January 29, 1971.

SIRS: We have the honor to submit herewith the Annual Report of the United States Atomic Energy Commission for 1970 as required by the Atomic Energy Act of 1954.

Respectfully,

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

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

CONTENTS

Chapter 3—Licensing and Regulating the Atom

Chapter 4—Source, Special, and Byproduct Nuclear Materials

Chapter 5—National Defense Programs

Chapter 6—Reactor Development and Technology

Chapter 7—Space Nuclear Systems

Chapter 8—Isotopic Systems Development

Chapter 9—Peaceful Nuclear Explosives

Chapter 10—International Affairs and Cooperation

Chapter 11—Nuclear Educational Activities

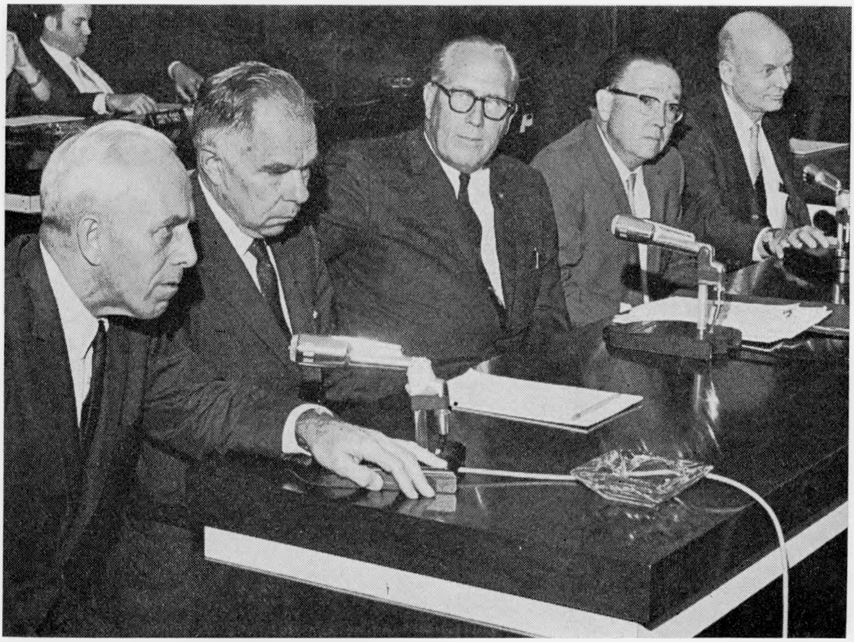
Chapter 12—Biomedical and Physical Research

Chapter 13—Administrative and Management Matters

Chapter 14—License Reviews and Adjudicatory Proceedings

Appendices

Index



The Atomic Energy Commission, during most of 1970, was composed of (*left to right*) Commissioner Wilfrid E. Johnson, Chairman Glenn T. Seaborg, Commissioner Clarence E. Larson, Commissioner James T. Ramey, and the late Commissioner Theos J. Thompson. Dr. Thompson died November 25 in a Nevada airplane crash that also took the life of his special assistant, Lt. Colonel Jack Rosen (U.S. Army—Ret.), and Bill Smith, an employee of an AEC contractor at the Nevada Test Site. The small plane crashed into Lake Mead, southeast of Las Vegas; the National Park Service pilot, although seriously injured, survived. Dr. Thompson and Colonel Rosen had made the flight to study the terrain surrounding the weapons test site. Dr. Thompson, formerly Professor of Nuclear Engineering and Director of the Massachusetts Institute of Technology's nuclear reactor facility, had been sworn in as a Commissioner on June 12, 1969, to fill the unexpired term of Dr. Gerald F. Tape, resigned. Born in Lincoln, Nebr., on August 30, 1918, he had quarterbacked the University of Nebraska football team against Stanford University in the 1941 Rose Bowl game. He was awarded his Ph. D. in nuclear physics in 1952 by the University of California while working as a physicist in the forerunner of today's Lawrence Radiation Laboratory at Berkeley. Prior to joining the MIT staff and faculty he had been a staff physicist at the Los Alamos Scientific Laboratory. Colonel Rosen, prior to assignment as a staff consultant to the congressional Joint Committee on Atomic Energy (JCAE) had been assigned to the AEC's Division of Military Application. He left the JCAE staff in 1967 to be Dr. Tape's special assistant. At yearend, President Nixon had not named a replacement for Dr. Thompson.

An Introduction To:

THE ATOMIC ENERGY PROGRAM DURING 1970

With the pace of growth set by the atomic power segment, the future character of the burgeoning nuclear industry became even more apparent during 1970. All indications point toward a strong and viable future.

With each new order by an electric utility of a nuclear powerplant, the many-faceted base supporting this one segment of the nuclear industry gains in competitive and economic strength. Each order has its effect on uranium mining and milling, on feed material processing and fuel fabrication, on fabrication of components—from the heavy steel pressure vessels to the delicate instrumentation that goes into reactors—and on the reprocessing of "spent" fuel elements to retrieve useful uranium and plutonium and valuable radiosotope byproducts. All of these, and other segments of the industry, showed continued growth during 1970. Above all, the new nuclear powerplants coming "on stream," and those planned for the future, lessened the spectre of power "brownouts" and "blackouts" in the years ahead.

Indicative of the faith that utilities have in the safety of nuclear powerplants is the fact that of the 14 new reactors ordered in 1970, 12 of the multi-million-dollar units will be located within a few hundred feet of other units. In fact, at the end of 1970, there were 67 sites in 28 States (plus one in Puerto Rico) at which 108 nuclear power units were either in operation, under construction, or contractually planned; and at 33 of these sites there are, or will be, multiple units involving two or three reactors. Indeed, to alleviate foreseen future power shortages in the Pacific Northwest it has been suggested that as many as eight power reactors be located within a "nuclear park" in southeastern Washington. The table on p. 2 shows the growth of nuclear generating capacity over the past 5 years. While the nuclear power generating capacity today constitutes only about 1.8 percent of the national electrical energy total, it is anticipated that by 1980, the nuclear generating capacity will be about 150,000 Mwe. or nearly 25 percent of the Nation's total capacity.

An unprecedented safety record has been established in power reactor operations—there has not been a single radiation injury to the general public or any plant employee. However, the word "radiation" continued, through erroneous assumptions and misrepresentation of facts, to conjure a feeling that nuclear power, if allowed to continue its growth, would unduly endanger the health and welfare of the Nation's population. Many of the questions raised overlooked the fact that the risks associated with radiation—not only with regard to nuclear powerplants but also in connection with all types of atomic activities—have probably been more thoroughly studied and are better understood than any other potential industrial environmental factor. During 1970, the AEC was sponsoring more than 1,070 individual research studies directly or indirectly concerning environmental aspects of radiation. Thus, while the biological risks of many other environmental factors may be largely unknown, the storehouse of useful information on radiation is growing daily.

Under the Atomic Energy Act of 1954, the AEC had no regulatory authority over environmental matters except for radiological health and safety considerations. However, the President's signing of the National Environmental Policy Act, and the subsequent Federal actions—new agencies, new laws, new programs—to implement the act, gave added impetus, through added responsibilities, to the AEC's already longstanding concern with the environmental aspects of nuclear activities. During December, the AEC published a revised environmental policy statement that provides for fuller consideration of environmental issues in its licensing of nuclear powerplants. With many more nuclear plants foreseen and a general recognition that their warm-water discharges might change the character of a body of water, the nuclear power industry has already shown a trend toward greater

	Nuclear units ordered	Installed capacity (Mwe.)
1970	14	14,336
1969	7	7,225
1968	16	14,791
1967	31	25,941
1966	20	16,306
Thru 1965:	27*	8,435
Totals	115*	87,064

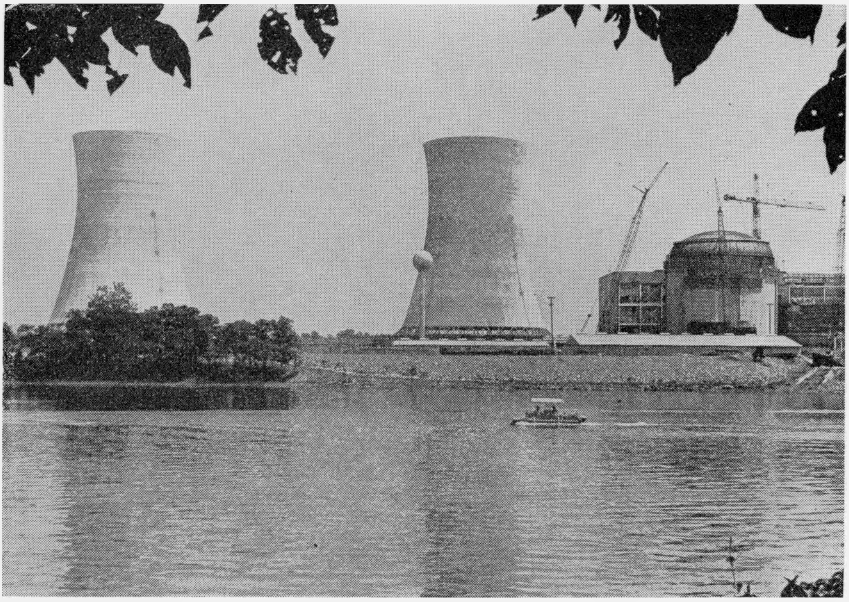
*Includes seven small prototype plants no longer in operation or which are now used only for experimental work.

use of cooling systems where the heated water is not immediately returned to the source from which it was drawn.

CONTENTS SUMMARY

The "highlights" included on a chapter-by-chapter basis on the next 14 pages very briefly summarize some of the more noteworthy activities of the year appearing in this "Annual Report to Congress for 1970."[1] New discoveries and advancements made in the areas of

[1] This "Annual Report to Congress for 1970" is available to the public under an alternate title, "Major Activities in the Atomic Energy Programs—January–December 1970," from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.75.



Giant Cooling Towers, to reduce the temperature of the water discharged from a nuclear powerplant, are being included in the plans for more and more plants. At the end of 1970, such towers were included for more than 22 of the nuclear units now under construction or planned. Air drawn into the towers through the openings at the bottom, cools the water as it flows down the interior of the towers. *Above* is a view of the first unit (dome at *right*) of the Metropolitan Edison Co.'s Three Mile Island Nuclear Station located on the Susquehanna River about 10 miles south of Harrisburg, Pa. The two 372-foot natural draft cooling towers will prevent any significant change in the temperature of the Susquehanna since the cooled water will be reused over and over and the water will be taken from the river only to replace that lost by evaporation. Three Mile Island's first Babcock & Wilcox 810-Mwe. pressurized water unit will go into operation in 1972; a twin unit is scheduled for 1973 operation.

412–406—71——2

basic research and exploratory development are summarized in the supplemental report, "Fundamental Nuclear Energy Research—1970." [2]

---

[2] "Fundamental Nuclear Energy Research—1970" is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.75.

The Atomic Pioneer Award, a unique award created for Dr. Vannevar Bush, Dr. James B. Conant, and Lt. General Leslie R. Groves, was presented by President Nixon at White House ceremonies on February 27, 1970. In the photo, AEC Chairman Glenn T. Seaborg holds the framed citation, as the President presents the Atomic Pioneer medal to Dr. Bush with Dr. Conant and (the late) General Groves looking on. The three atomic pioneers played a major role in World War II development of nuclear weapons and subsequent government sponsorship of scientific research. Dr. Bush had general responsibility for organizing the abilities and resources of the nation's scientist during World War II to work on nuclear energy and other defense developments. Dr. Conant, working with Dr. Bush, had special responsibilities for the initial scientific research which demonstrated the possibility of using nuclear energy for military purposes. General Groves, who died in July of 1970, was in the Corp of Engineers and obtained the highest wartime material priorities for the Manhattan Project. General Groves provided much of the drive and sense of urgency that made the project successful. The three awardees served in positions closely associated with the Atomic Energy Commission's activities for several years following the AEC's takeover from the Manhattan Engineer District in 1947.

1. The Industrial Base

● New orders for nuclear power reactors continued to provide an expanding economic base for the overall nuclear industry; 14 new units with a design capacity of 14,336 megawatts of electricity (Mwe.) were contracted for in 1970.

● Five new nuclear central station powerplants began operation during the year, adding 3,203 Mwe. (net) to the Nation's electric power supply and bringing to 19 the number of operable central station nuclear reactors at the end of 1970; another 53 nuclear units were under actual construction at yearend, and 36 others had been contracted for but were not yet under construction.

● At current prices, the nuclear power units now ordered will represent a commitment by industry for plants and nuclear fuel over a 30-year operating period of about $80 billion.

● U.S. Bureau of Census industrial surveys showed a continuing growth in the shipments of nuclear products; the latest figures available showed a 14-percent increase over the previous year.

2. Environmental and Related Aspects

● AEC laboratories are carrying out over 50 separate projects for other Federal agencies in the field of environmental and health-related research. Current support for these interagency projects exceeds $10 million. The AEC has entered into 40 or more agreements with other agencies for work related to the study or monitoring of the environment.

● The AEC has developed the necessary technology for greater reduction of noble gas effluents from nuclear powerplants. A process in which 99 percent of these gases (krypton and xenon) are absorbed by an organic solvent has reached the pilot plant stage of development at Oak Ridge.

● A new thermal effects research facility is being built at the Savannah River Plant for use in obtaining data useful to both nuclear and nonnuclear industries.

● Four new double-shell type tanks for storing radioactive wastes were placed in service at the AEC's Savannah River Plant. Construction was completed on two similar tanks at the Hanford Works and four more tanks are under construction: Two at Hanford, and two at Savannah River.

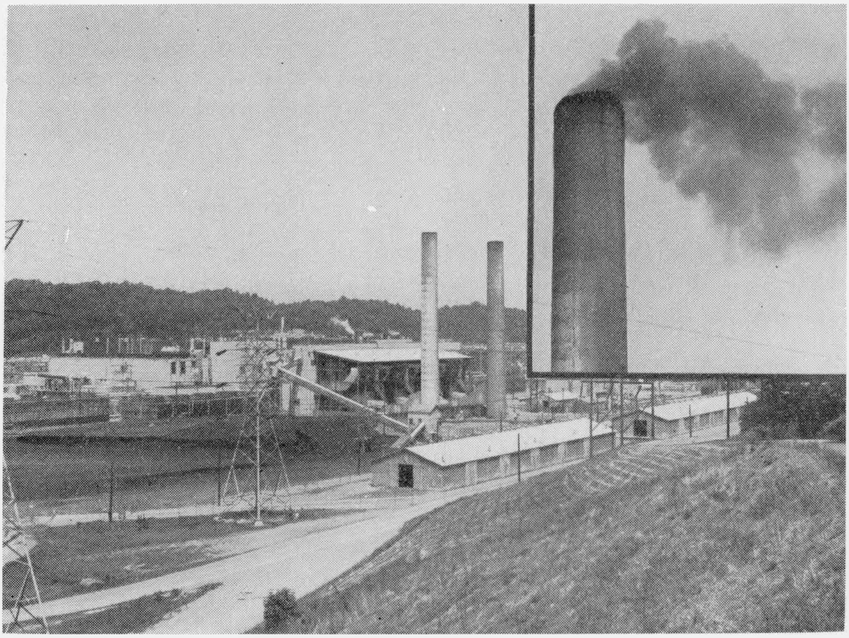
● Site feasibility studies are underway for long-term storage of radioactive wastes in salt deposits near Lyons, Kansas.

● During underground weapons testing, two accidental leakages of radioactivity were of sufficient quantity to be detected off the Nevada Test Site. One of them resulted in low-level radiation exposure to on-site workmen and to a few individuals living near the test site boundaries.

3. Licensing and Regulating the Atom

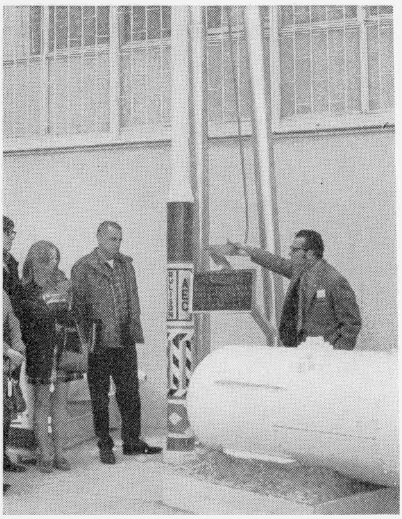
● Implementation of new environmental quality legislation involved enlargement of AEC regulatory responsibilities concerning nonradiological effects of licensed nuclear facilities, and transfer to another agency of the AEC's standards setting functions for generally applicable environmental radiation standards.

● "Practical value" amendments of the Atomic Energy Act at the



"Before" and "After" Photos of the steam generating plant stacks of the AEC's Y–12 Plant at Oak Ridge, Tenn., show the results of installing electrostatic precipitators on each of the four pulverized-coal-fired boilers. The precipitators, placed between the boilers and the stacks, reduced the flyash discharge from the stacks to the atmosphere from about 4,000 tons per year (*inset photo*) to approximately 180 tons a year (note "clean" stacks in large photo). Besides such practical applications at its facilities, the AEC has a large number of research studies underway at its national laboratories—many in conjunction with other Federal or local agencies—aimed at controlling environmental contamination by industrial operations.

The 1970 Fermi Award was presented to Dr. Norris E. Bradbury, director of the Los Alamos Scientific Laboratory (LASL) from 1945 to 1970, as part of the public ceremony in his honor upon his retirement. Dr. Bradbury received the award from AEC Chairman Seaborg on August 29, 1970. He was selected by the Commission and the award had the approval of the President. The Fermi Award is made for outstanding scientific achievements, or contributions to engineering and technical management in the development of atomic energy. It is named for the late Dr. Enrico Fermi who, in 1942 at the University of Chicago, led his scientific team in obtaining the first successful sustained nuclear chain reaction. The presentation consists of $25,000, a gold medal, and a citation. Dr. Bradbury's citation reads: "For his inspiring leadership and superb direction of the Los Alamos Scientific Laboratory throughout one-quarter of a century, and for his great contributions to the national security and to the peacetime applications of atomic energy." As a part of the Fermi Award ceremonies, the museum at LASL was renamed the "Norris E. Bradbury Science Hall and Museum." Photo at *left* shows a museum tour guide explaining the models of two nuclear devices in which Dr. Bradbury played a part in developing—the peaceful uses of nuclear explosives "Rulison" device used in the 1969 Plowshare experiment in Colorado, and the "Little Boy" bomb, *lower right*, the first nuclear weapon used in war on August 6, 1945, over Hiroshima, Japan. Last year, the museum drew 80,000 visitors from every State in the Union and from 87 foreign countries.

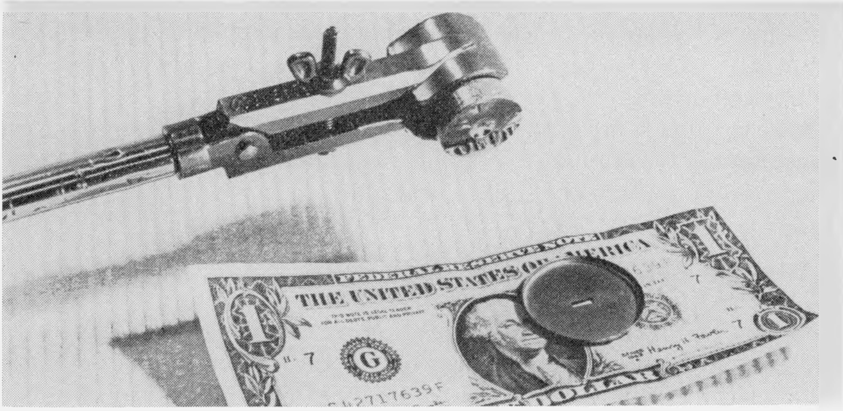


end of the year made applications for licenses for all commercial or industrial nuclear facilities subject to antitrust review by the Attorney General and the AEC.

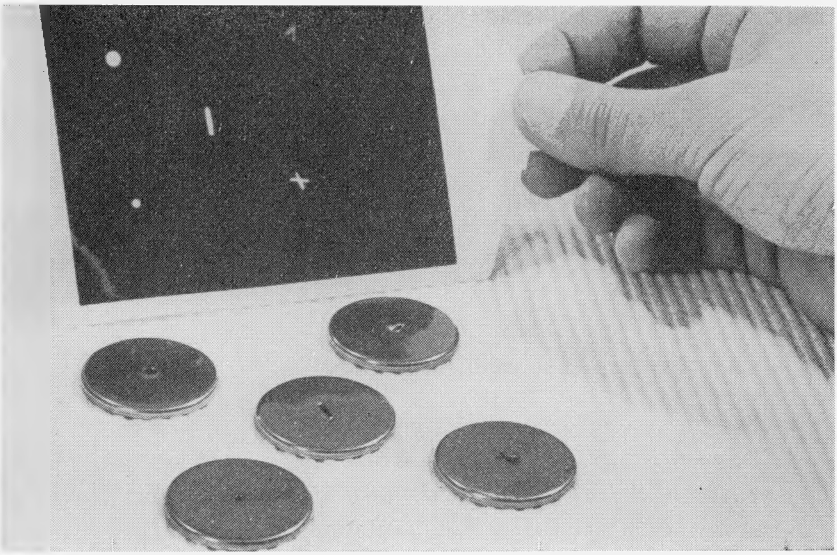
- During 1970, the AEC licensed four power reactors for operation and authorized the construction of 10 new nuclear central station powerplant units. At yearend, applications were under review for operation of 27 units, and construction of 30 units.
- The continual broadening of the nuclear industrial base was demonstrated by the licensing of two new facilities, near Gore and Crescent, Okla., for processing fuel materials for power reactors; issuance of a construction permit for the Nation's third plant (Barnwell, S.C.) to reprocess "spent" nuclear fuels, on December 18; and receipt of an application to construct another such plant (Leeds, S.C.) on October 29, 1970.
- Maryland executed an agreement to become the 23d State (effective Jan. 1, 1971) to assume regulatory authority from the AEC over byproduct materials, source materials, and small quantities of special nuclear materials.

4. Source and Special Nuclear Materials

- Industry exploration activity in 1970 was about 20 percent lower than the 1969 record level but a preliminary analysis indicates that uranium reserves increased by about 39,000 tons to total some 243,000 tons by yearend.
- The AEC, having completed its uranium procurement program, plans no new uranium purchases. During the past 24 years, the AEC has purchased 316,000 tons of U_3O_8 in concentrates from all sources.
- With the signing of its 53d domestic and foreign toll enrichment contract in November, the AEC's service surpassed the two billion dollar mark ($2.3 billion) in orders that will be performed over a 30-year period.
- Californium-252, the new manmade radioisotope that is an intense neutron emitter, continues to show varying beneficial uses as larger quantities become available for research and development studies from the Savannah River production reactors. The AEC announced plans, in August, to sell relatively large quantities of the radioisotope at $10 per microgram, beginning in early 1971; previously a price of $15 to $25 per microgram had been foreseen. To date, only relatively small quantities have been available, at a sale price of $100 per one-tenth of a microgram.
- Two mobile nondestructive assay laboratories developed by the Los Alamos Scientific Laboratory and Gulf Radiation Technology



Money, Marked Invisibly by Nuclear Methods, may become a legal nemesis to criminals. By aiming a californium-252 source through the aperture of a die (*above*), the money can be imprinted with a slightly radioactive mark in an infinite variety of patterns. The resultant nuclear markings can be read only through the use of high-speed X-ray film placed in contact with the money, as shown in the Argonne National Laboratory photograph *below.* The nuclear markings, which in no way constitute a health hazard, fade to a barely detectable level after a short period. By use of a pre-selected die, a pattern can be placed on almost any solid material through the presence of radioactive fission fragments (emitted by the spontaneously-fissioning californium) and which adhere to the exposed material. The technique can be used as a nuclear "invisible ink" to encode documents, identify ransom money, or secretly mark almost any material.



began field tests to demonstrate and evaluate nondestructive assay techniques for special nuclear materials as a part of the AEC's program to further safeguard such materials against diversion to unauthorized uses.

● Four firms have joined in demonstrations of nondestructive measurement techniques in five operating plants to provide safeguards control on plutonium or enriched uranium.

5. National Defense Programs

● The major portion of restoration of the production capability and plutonium decontamination work at the Rocky Flats Plant was completed by May 8, 1970, just 52 weeks after a $45 million fire had severely reduced the plant's production capacity.

● The 1970 weapons test program was interrupted by a 4-month strike of construction workers at the Nevada Test Site; 29 defense-related tests were announced during the year.

● The sixth and final launch of AEC-instrumented Vela satellites in April added improved detection equipment to the U.S. space surveillance effort. Since the first twin-satellite launch in 1963, the joint AEC–DOD program has put 12 detection satellites into orbit to detect possible clandestine nuclear detonations in the atmosphere and deep space.

● The keels of two nuclear-powered guided missile frigates were laid at Newport News, Va.—the *California* (DLGN 36) on January 23, and the *South Carolina* (DLGN 37) on December 1.

● The keel of the nuclear aircraft carrier *Dwight D. Eisenhower* was laid at Newport News, Va., on August 15. This ship will be the second of the *Nimitz* class of carriers and will be able to operate 13 years without refueling the two reactors used for propulsion. The *Enterprise* was undergoing refueling of its eight reactors, the second since its 1961 commissioning. In 9 years of operation, the carrier steamed more than 500,000 miles including four deployments off Vietnam.

6. Reactor Development and Technology

● The highest priority efforts continued to be placed on the activities designed to achieve the successful development of safe, reliable, and economic liquid metal-cooled fast breeder reactors. The efforts are leading to: Mixed oxide fuel development; achievement of physics data required for the design and operation of fast breeder reactors;

development of breeder reactor design technology, instrumentation, and plant components and reactor equipment; design and construction of new and improved test facilities, particularly the Fast Flux Test Facility (FFTF); operation of test and experimental facilities; and arrangements permitting the construction and operation of liquid metal fast breeder reactor (LMFBR) demonstration plants. Work also continued on other breeder reactor concepts: Light water, molten salt, and gas-cooled.

● The 330-Mwe. Fort St. Vrain high-temperature gas-cooled reactor (HTGR) at Plattesville, Colo., is about 80 percent complete.

A Boeing 747 Flies Past a 200-Foot Instrument Tower at the AEC's National Reactor Testing Station (NRTS) in Idaho in the photo *above.* The flight was part of a cooperative Federal program to obtain data on low-altitude wake turbulent from large jet aircraft. Participating in the studies at the NRTS were the Federal Aviation Administration, the Environmental Science Services Administration (which, on October 5, became the National Oceanic & Atmospheric Administration) and the AEC. In addition to the "747," six other types of aircraft including the Lockheed C5A cargo craft, were flown during the February 1970 tests at the NRTS to measure the violent whirlpools of turbulent air generated by the wingtips and engines of modern jet aircraft. The data helped to establish a better understanding of wake turbulence and determine safe separation distances between aircraft. In addition to Idaho tests, two series of sonic boom research flights over the 1,527-foot-high Bren Tower on the AEC's Nevada Test Site (NTS) were made by National Aeronautics and Space Administration (NASA) aircraft. A total of 42 passes over the tower were made from October 22 through October 30. Purpose of the flights was to gather additional data on low-intensity sonic booms. The data obtained will be processed and correlated with that from other sonic boom studies. Because of their remote locations, the NRTS and NTS flights were made without inconvenience to the public.

This plant is based upon an extrapolation of the HTGR technology demonstrated in Peach Bottom Plant No. 1 at Peach Bottom, Pa.

- Results from the plutonium recycle program indicate that recycling of plutonium in light water reactors could be technically and economically feasible.
- The Fast Neutron Generator at Argonne National Laboratory began operations and the Zero Power Reactor No. 3 (ZPR-3) at the National Reactor Testing Station was shut down after 15 years of service.
- The Experimental Breeder Reactor No. 2 (EBR-2) achieved a plant factor of about 58 percent during 1970, and routine 62.5 Mwt. operation was started. It achieved a total operation of 1 billion Kwh. (thermal) early in November. An instrumented subassembly containing LMFBR fuel experiments was successfully operated in the EBR-2.
- Conceptual design of the Fast Flux Test Facility was completed, and procurement and fabrication of principal components were initiated.
- The project definition phase of the LMFBR Demonstration Plant project was initiated.
- The AEC continued its reactor safety program, with attention continuing to center on the light water reactor and LMFBR safety programs.

7. Space Nuclear Systems

- Development activities on a nuclear engine for rocket vehicle application (NERVA) concentrated on the definition and preliminary design of a flight-rated NERVA engine.
- A candidate fuel element for NERVA successfully completed 10 hours of electrical corrosion testing including 60 thermal cycles.
- A Pewee-2 experimental reactor was fabricated and delivered to the Nuclear Rocket Development Station in Nevada for testing in early 1971.
- The AEC selected a contractor to continue the development of a thermionic reactor for space applications with reactor experiment planned for the mid-to-late 1970's.
- The SNAP-19 nuclear generator operating on NASA's Nimbus weather satellite and the SNAP-27 nuclear generator placed on the moon by the Apollo-12 astronauts both passed 1 year of continuous operation.
- Four men completed a 90-day test in a space simulation chamber, during which time their entire water requirements were provided by

recycling their wastewater through a radioisotope-powered water recovery system.

8. Isotopic Systems Development

● With the completion of long-term animal feeding tests on irradiated strawberries without adverse results, a petition for approval for general public consumption of the fruit is to be submitted in 1971

The AEC's 1970 E. O. Lawrence Memorial Award was presented to five U.S. scientists on May 28 in ceremonies at the National Academy of Sciences in 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 those honored received a citation, a gold medal, and $5,000. The 1970 Lawrence awardees were *left* to *right:* Dr. Andrew M. Sessler, Lawrence Radiation Laboratory, Berkeley, "for many outstanding contributions to the field of high energy particle accelerator theory;" Dr. Michael M. May, Lawrence Radiation Laboratory, Livermore, "for his early and original contributions to the applications of computer techniques and theoretical calculations important to the design of nuclear weapons;" Dr. Joseph M. Hendrie, Brookhaven National Laboratory, "for his outstanding contributions to the physics and engineering of versatile research reactors and for important contributions . . . in promoting the safety of large power reactors;" Dr. William J. Bair, Pacific Northwest Laboratory, "for his studies of the deposition and movement of inhaled radioactive particles in the pulmonary system;" and Dr. James W. Cobble, Professor of Chemistry, Purdue University, Lafayette, Ind., "for outstanding contributions to the physical chemistry of aqueous electrolyte solutions and to the chemistry of technetium, the lanthanides and actinides." Commissioners Johnson, Ramey, Thompson, and Larson are seated; Dr. Seaborg, the AEC Chairman is at the speaker's stand. The annual Lawrence Award is made to recognize the current work of younger scientists in the Nation's atomic energy program. The award was established in 1959.

to the Food and Drug Administration. Two-year animal feeding studies on irradiation-pasteurized fish are scheduled to begin in 1971.

● A radioisotope-activated self-luminous highway sign, installed in Phoenix, Ariz., is successfully guiding traffic at night.

● A portable, 100-pound atomic camera that can "see" through metals to spot flaws or detect hidden drugs or narcotics has been developed at the Pacific Northwest Laboratory. The new camera uses the neutrons from a californium-252 source to penetrate heavy opaque materials.

9. Peaceful Nuclear Explosives

● Radiochemical analysis of natural gas samples taken from the Rulison well near Grand Valley, Colo., showed the tritium (radioactive hydrogen) in the gas is lower than expected and four to five times less than that from Gasbuggy, the first experiment to stimulate gas production through nuclear explosives.

● A cooperative study is being conducted to examine the economic and technical feasibility of using nuclear explosives to tap dry geothermal formations for use in generating electric power.

10. International Affairs and Cooperation

● On March 5, 1970, the U.S. and the U.S.S.R. deposited their instruments of ratification of the Treaty on the Non-Proliferation of Nuclear Weapons. This action, along with similar action of the United Kingdom and 45 nonnuclear states, brought the treaty into force. The treaty is designed to prevent diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices in nonnuclear weapon countries party to the treaty.

● With the assignment of five U.S. high-energy physicists at Serpukhov, the first Soviet-American collaborative experiment in the nuclear sciences was initiated under the U.S.-U.S.S.R. Memorandum of Cooperation. Ten U.S. nuclear reactor specialists toured laboratories and nuclear power installations in the U.S.S.R. for 2 weeks in June and July. This visit reciprocated the tour of U.S. facilities made by Soviet reactor specialists in November 1969.

● As of the end of 1970, the Export-Import Bank of the United States had authorized approximately 18 projects involving American-supplied materials and equipment in nuclear plants abroad. These authorizations total approximately $600 million and involve a nuclear-power capacity in excess of 6,000 megawatts in plants in France, Republic of China (Taiwan), Germany, Italy, Japan, Korea, and Spain.

11. Nuclear Educational Activities

- In 1970, over 2,605 faculty and 7,013 students from 799 institutions in 49 States participated in laboratory cooperative programs at AEC national laboratories and other specialized contractor-operated facilities.
- The educational programs at the AEC's Puerto Rico Nuclear Center (PRNC) facilities at Rio Piedras and Mayaguez continued to strengthen the capabilities of Latin American countries for the peaceful uses of nuclear energy.
- A remote access computerized technical information system functioned in 1970 with a successful transcontinental and transoceanic linkup over a distance of 6,000 miles.
- The AEC made its first exchange of technical information through the International Nuclear Information System formally initiated by the International Atomic Energy Agency (IAEA).
- Preliminary design was completed for the U.S. exhibit to be presented at the Fourth United Nations Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland, during September 1971.
- During 1970, some 12,000 documents were declassified and made available to the public. In addition, reviews resulted in a reduction in the number of classified documents stored at AEC contractor facilities thus reducing expensive storage facilities.
- A total of 232 United States and 476 foreign patents were issued to the AEC during the year. The AEC issued eight public announcements of new U.S. and foreign patents available for licensing. Some 120 nonexclusive licenses were granted on U.S. patents and patent applications.

12. Biomedical and Physical Research

- Some 30 of the more noteworthy advances in the life and physical sciences fields of research are highlighted from the supplemental report "Fundamental Nuclear Energy Research—1970." AEC-sponsored research continued under nearly 1,184 biomedical and physical science research projects at some 260 colleges, universities, and other research institutions, in addition to the research conducted in AEC laboratory facilities.
- The world's most powerful Van de Graaff accelerator system—a double tandem device—surpassed its design performance specifications at Brookhaven National Laboratory in June when a 30.5-Mev. (million electron volts) beam of protons was produced.

● Construction of the Los Alamos Meson Physics Facility (LAMPF) is proceeding at a pace that will permit a first beam (800 Mev.) by July 1972 and an active experimental research program by July 1973. Upon completion, the LAMPF proton linac will be the world's most prolific meson-producing accelerator.

● Construction of the National Accelerator Laboratory at Batavia, Ill., is on schedule; overall construction is 40 percent complete. With the 200-Bev. accelerator expected to be operational in 1973, a program advisory committee was established during 1970 to screen the more than 90 proposals for experiments already received.

The Discovery of Element 105, long sought by nuclear physicists, was reported in April 1970 by an international team working at the AEC's Lawrence Radiation Laboratory, Berkeley. The same team had, in 1969, discovered element 104. The team, *left to right:* Matti Nurmia, a physicist formerly with the University of Helsinki, Finland; James A. Harris, a nuclear chemist; Kari A. Y. Eskola and his wife, Pirkko, visiting physicists from the University of Helsinki, Finland; and Albert Ghiorso, leader of the group and a 25-year veteran of new-element hunting who has now participated in the discovery of elements 95 through 105. Element 105 was made by bombarding a target of 60 micrograms (two-millionth of an ounce) of californium-249 (element 98)—also a rare manmade isotope—with a beam of 84 Mev. (million electron volts) nitrogen nuclei in the Heavy Ion Linear accelerator (HILAC). The name hahnium (symbol: Ha), after the late German scientist Otto Hahn—discoverer of nuclear fission—was suggested for the new element. The half-life of the discovered hahnium-260 isotope was measured at 1.6 seconds—much longer than the thousandths-of-a-second half-life that had been predicted on the basis of knowledge gained from other elements.

13. Administrative and Management Matters

● Employment in the atomic energy field rose from 148,996 to 154,076 between May 1969 and May 1970.

● Strikes against AEC contractors at Government-owned facilities during 1970 accounted for 512,080 man-days of lost time or 1.07 percent of the estimated working schedule.

● Employment of members of minority groups, as a percent of the total AEC contractor work force at Government-owned facilities, rose from 8.5 percent in 1968 to 10.5 percent in 1970.

● AEC contractors at Government-owned facilities employed 871 young people under the Youth Opportunity Campaign during the summer of 1970; the AEC employed 228 young people.

● At yearend, proposals to turn part of the AEC's Hanford Works near Richland, Wash., into a vast nuclear park were under consideration. Site problems in the coastal areas of Washington and Oregon led to proposals for the establishment of up to eight 1,000-Mwe. powerplants at Hanford to alleviate the Northwest's power shortage. During October, the Washington Public Power Supply System announced its intention to locate an 1,100-Mwe. nuclear powerplant at Hanford.

● Another contractor, WADCO (a subsidiary of the Westinghouse Electric Corp.), assumed operation of the Hanford Engineering Development Laboratory (HEDL), with responsibility for most of the reactor development-related work as well as the management of the Fast Flux Test Facility construction previously done by the Battelle-Northwest Division of the Battelle Memorial Institute.

● After 2 years of operation, the AEC's central radiation records repository at Oak Ridge has records of about 55,000 persons on file who, through their employment, have been exposed to radiation; records of the more than 200,000 personnel monitored in each of 2 years show that only about 2 percent of them receive annual exposures exceeding the quarterly limits of 1.25 rems whole body.

● AEC subcontracting to small business remained relatively steady during the period 1967–70, the percentage figures for the 4 years being 43.5, 45.4, 44.3, and 43.1, respectively.

Chapter 1

THE INDUSTRIAL BASE

The ever-increasing impact of the Nation's atomic energy program can best be measured by the growth of the nuclear power industry. As more new central station nuclear powerplants are contracted for, the various segments of industry providing the materials and services for the construction and operation of these plants become more viable and a stronger competitive base is built up. Each new plant adds to the raw uranium ore requirements of the future; provides more work for the components fabrication industry; and increases the requirements for trained technical and professional personnel to perform the complex functions associated with plant construction and operation.

The Nuclear Industrial Base

Years of development, supported by Government and by industry, have made possible the creation of a substantial capability to provide nuclear powerplants of proven design. In the United States alone, it is estimated that existing manufacturing facilities are capable of producing a total of about 20 large nuclear plants a year. In support, there is ample capacity to carry out all steps of the fuel cycle, with only the uranium enrichment function solely a Government service.

Approximately 155,000 people in the United States depend on atomic energy for their livelihood. Employment at Government-owned, contractor-operated establishments has remained relatively stable for several years at about 100,000. However, in the private nuclear sector employment has been increasing at a rapid rate and stands today at about 55,000. Most of these are engaged in the manufacture, design, and engineering of nuclear facilities. Approximately 3,000 utility employees are assigned to the operation, maintenance, and technical support of power reactors.

Atomic energy also is well represented in the academic world. About

412-406—71——3

Uranium's Great Advantage as a Fuel for the production of electricity has to do with the enormous amount of energy it stores in comparatively little space. For instance, a cube of uranium roughly an inch square contains enough energy to supply a six-room home with electricity and heat for a thousand years. On a comparative basis, 1 pound of uranium—a piece the size of a golf ball— has the same energy potential as the 3 million pounds of coal that would require 35 railroad cars to haul. Unlike other fuels that are burned at once, the uranium fuel loading in a nuclear plant lasts about 3 years before becoming "spent".

250 colleges and universities have a current enrollment of over 6,000 U.S. students in course work leading to degrees in nuclear science and engineering, and this number is expected to increase to over 7,000 by 1973 as industry's demand for qualified personnel continues to grow.

The Nuclear "Base Load"

The anticipated supply of fossil-fuels for electric power generation is such that a utility planning future expansion of its generating facilities now weighs the costs and efficiency of nuclear plants against the costs and availability of supplies and fossil fuels. In many areas of the country, higher initial capital costs of nuclear plants are offset by savings from lower fuel costs—current reactors need to be refueled only one in about 3 years. Thus, in more and more situations, the nuclear plants are being selected on a purely competitive basis over the coal, gas, or oil-fired units.

Each new plant enhances the ability of the electric utility industry to meet the Nation's growing needs for more power in a clean and efficient manner. Central station powerplants—conventional or nuclear—take considerable time from the day they are contractually planned to the day they go "on stream" and the power industry must continually plan for the future. The new nuclear plants ordered in 1970 are to meet the "base load" electric energy needs foreseen for the 1975–79 period—the economics of nuclear plants is such that they must be operated at a high-load level throughout their life; they are not suitable for "peak" or "swing" operations that may account for only about 2,000 hours of plant operation in a year.

GROWTH OF NUCLEAR POWER

During 1970, five new nuclear power reactors began operations, and utilities contracted for 14 more nuclear units, making a yearend total of 108 central station nuclear power reactors with a net generating capacity of 86,103 Mwe. (megawatts of electricity) under contract, under construction, or operable in the United States. One new State, Louisiana, was added to the nuclear plant map during the year.

New Plants in Operation

The five new plants going into operation in 1970 have a total net generating capacity of 3,203 Mwe. The plants, their location, capacity, and date of initial criticality (ability to sustain a fission reaction):

Dresden Nuclear Power Station, Unit 2, Morris, Ill., 809 Mwe., on January 7;

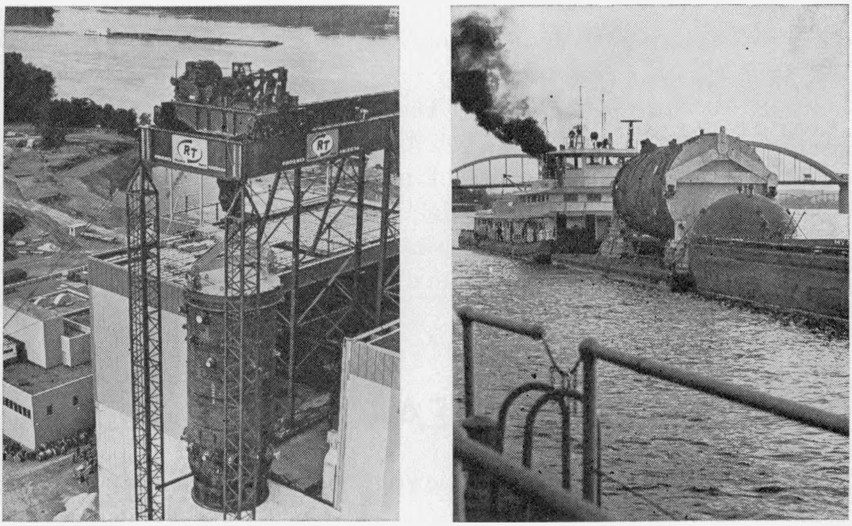
H. B. Robinson S.E. Plant, Unit 2, Hartsville, S.C., 700 Mwe., September 20;

Millstone Nuclear Power Station, Unit 1, Waterford, Conn., 652 Mwe. on October 27;

Point Beach Nuclear Plant, Unit 1, Two Creeks, Wis., 497 Mwe., on November 2; and

Monticello Nuclear Generating Plant, Monticello, Minn., 545 Mwe. (low power operation), on December 10.

In addition, Unit 1 of the Enrico Fermi Atomic Power Plant at Lagoona Beach, Mich., resumed operation July 18, 1970, after being



The 800-ton Alloy Steel Vessel had to be hoisted 100-feet "up-over-and-down" into the reactor building at the Commonwealth Edison Co.'s Quad-Cities nuclear power station near Cordova, Ill., about 150 miles west of Chicago. Almost seven stories high, the vessel was shipped about 660 miles by barge along the Ohio and Mississippi Rivers from the Babcock & Wilcox fabrication plant at Mount Vernon, Ind. Steam produced in the reactor vessel will spin a turbine-generator. Quad-Cities station will consist of two 809 Mwe. nuclear units scheduled for service in 1971 and 1972, respectively. Iowa-Illinois Gas & Electric Co. has a one-quarter ownership interest in the two-unit boiling water plant being built by General Electric Co.

shut down in October 1966 because of a partial fuel meltdown caused by an obstruction in the cooling system. Following low-power testing, the reactor power was raised to its design level of 200 thermal megawatts in October 1970. At the end of the year, the plant was being operated intermittently as a part of the power demonstration program; the Power Reactor Development Co. was seeking to define a future program for the plant that would be consistent with the goals of the liquid metal fast breeder reactor (LMFBR) effort.

As indicated in Table 1, 16 plants—with a combined capacity of 12,226 Mwe.—are scheduled to begin operation in 1971.

NEW PLANTS ORDERED IN 1970

During the first 6 months of 1970, orders were placed for nine nuclear reactors with a total capacity of 8,410 Mwe. These orders, alone, were more than the 1969 contracts—seven units, totaling about 7,250 Mwe.

In August, the Tennessee Valley Authority contracted for four more units to augment the five it already had under construction or contract for an overall TVA total of 10,125 Mwe. One other reactor was ordered in December, making a total of 14 reactors ordered during 1970. Commonwealth Edison Co.'s contract for two more nuclear units gave it a big lead (total of 9 units, 8,692 Mwe.) among the investor-owned utilities.

The Orders by Months

January.[1] The Virginia Electric & Power Co., ordered an 845-Mwe. pressurized water reactor from Westinghouse Electric Corp. for installation as Unit 2 at the North Anna Power Station, Mineral, Va. The architect-engineer is to be Stone & Webster. Operation is scheduled for 1974.

Southern California Edison and San Diego Gas & Electric Co. ordered two 1,140-Mwe. pressurized water reactors from Combustion Engineering, Inc., for installation as Units 2 and 3 at the San Onofre Nuclear Generating Station at San Clemente, Calif., during January. Bechtel is to be the architect-engineer. Unit 2 is scheduled for 1975; Unit 3 for 1977.

---

[1] The Cincinnati Gas & Electric Co., the Columbia and Southern Ohio Electric Co., and the Dayton Power & Light Co. ordered an 810-Mwe. boiling water reactor in January from the General Electric Co. for a second unit at the William H. Zimmer Nuclear Power Station, Moscow, Ohio. However, in mid-November, the contract was canceled and the plans for this unit were indefinitely postponed. This unit is not included in Table 1 and is excluded from references to 1970 orders.

February. The Georgia Power Co. signed a contract with General Electric for a 786-Mwe. boiling water reactor to be installed as Unit 2 at the Edwin I. Hatch Nuclear Plant, Baxley, Ga. Southern Services Co., with assistance from Bechtel, will be the architect-engineer. Operation is scheduled for 1976.

March. The Commonwealth Edison Co. ordered two 1,078 Mwe. boiling water reactors from General Electric. Sargent & Lundy will be the architect-engineer. The reactors will be installed at the La Salle County Nuclear Station, Seneca, Ill. as Units 1 and 2. Unit 1 is to start up in 1975; Unit 2 in 1976. The twin order put Commonwealth Edison far in the lead among nuclear-oriented, investor-owned utilities with nine nuclear units (8,692 Mwe.) in operation, under construction, or under contract.

May. The Arkansas Power & Light Co. signed a contract with Combustion Engineering for an 950-Mwe. pressurized water reactor to be installed as Unit 2 at the Arkansas Nuclear One site, London, Ark. Operation is scheduled for 1976. Arkansas Power & Light has an option for another identical unit.

The Puerto Rico Water Resources Authority (PRWRA), in May, contracted with Westinghouse for a 583-Mwe. pressurized water unit with scheduled completion set for 1975. The plant will be located in Puerto de Jobos on Aguirre Bay, about 7 miles southwest of Guayama. (The plant will be the second nuclear unit for Puerto Rico; the Authority operated the 17-Mwe. BONUS experimental plant from 1964 to 1968. At the time the AEC–PRWRA project, located near Punta Higuera, was terminated because of continuing technical problems, the Authority indicated its interest in nuclear power would continue.)

August. The Tennessee Valley Authority (TVA) set another new world first in August when it ordered four reactors at one time through a split order. It contracted with Westinghouse for twin 1,170-Mwe. pressurized water reactors, to be located on the Tennessee River at Watts Bar Dam, and with Babcock & Wilcox for twin 1,201–Mwe. pressurized water units for installation at an undesignated site. (The TVA also was the first to contract for reactors having capacities in excess of 1,000 Mwe. and the first to submit a "double-header" construction permit application to the AEC—the Browns Ferry Units 1 and 2 near Decatur, Ala., which were contracted for with General Electric in 1966, and for which construction was authorized in 1967.)

September. The Louisiana Power and Light Co. ordered a 1,165-Mwe. pressurized water unit from Combustion Engineering. Ebasco Services, Inc., is to be the architect-engineer. The plant is scheduled to go into operation in 1976 at the Waterford Generating Station on the west bank of the Mississippi River about 25 miles from New Orleans. This is to be the first nuclear power station located in Louisiana. (In a construction permit application filed with the AEC on December 31, 1970, the utility indicated it plans to install a second similar unit at the site; however, no contract announcement for the second reactor had been made.)

December. The Alabama Power Co. ordered a second unit, an 829-Mwe. Westinghouse pressurized water reactor, for the Joseph M. Farley Nuclear Plant site at Dothan, Ala. Operation is scheduled for 1976.

Central Station Nuclear Powerplants

As indicated by the map below, the growing use of nuclear reactors for generation of central station power continues to be concentrated in the Eastern half of the U.S. with Illinois, New York, and Pennsylvania having the most plants; in the Western half, California leads.

The AEC's "N" reactor, near Richland, Wash., is shown on the map, but is not included in the Table 1 listings since it is not in the same category as the other powerplants listed. Built as a plutonium-production facility, the "N" reactor began furnishing steam, in 1966, to the adjacent Washington Public Power Supply System's 790-Mwe. generating station to become the Nation's only dual-purpose reactor (see p. 112 for operating details).

NUCLEAR POWER

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected

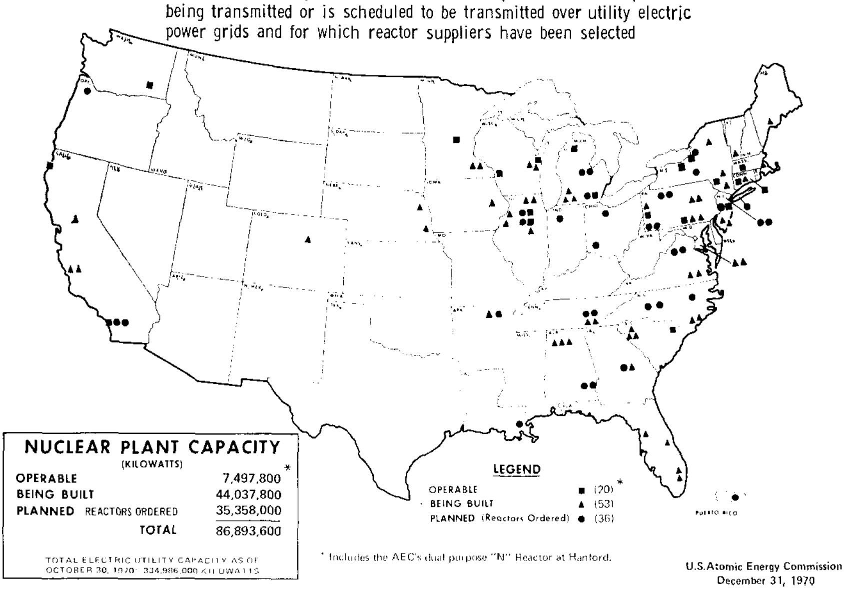


TABLE 1.—CENTRAL STATION NUCLEAR POWERPLANTS* UNDER CONTRACT

(In Operation (●), Construction authorized by AEC (+), or Contractually Planned)

Plant (site)	Operable ● Const. auth. +	Capacity (net Mwe.)[1]	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	1973
Joseph M. Farley Nuclear Plant (Dothan)				
Unit 1		829	Alabama Power Co	1974
Unit 2		829	do	1976
Arkansas:				
Arkansas Nuclear One (London)				
Unit 1	+	820	Arkansas Power & Light Co	1973
Unit 2		950	do	1976
California:				
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).	+	804	Sacramento Municipal Utility District.	1972
San Onofre Nuclear Generating Station (San Clemente)				
Unit 1	●	430	Southern California Edison, San Diego Gas & Electric Co.	1967
Unit 2		1,140	do	1975
Unit 3		1,140	do	1977
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 (Ford Pierce)				
Unit 1	+	813	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)				
Unit 1	+	786	Georgia Power Co	1972
Unit 2		786	do	1976

See footnotes at end of table.

TABLE 1.—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Con.

Plant (site)	Operable ● Const. auth. +	Capacity (net Mwe.)[1]	Utility/owner	Startup
Illinois:				
Dresden Nuclear Power Station (Morris)				
Unit 1	●	200	Commonwealth Edison Co	1959
Unit 2	●	809	do	1970
Unit 3	+	809	do	1971
LaSalle County Nuclear Station (Seneca)				
Unit 1		1,078	Commonwealth Edison Co	1975
Unit 2		1,078	do	1976
Quad-Cities Station (Cordova)				
Unit 1	+	809	Commonwealth Edison, Iowa-Illinois Gas & Electric.	1971
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).		660	Northern Indiana Public Service Co.	1976
Iowa:				
Duane Arnold Energy Center (Palo)				
Unit 1	+	545	Iowa Electric Light & Power Co., Central Iowa Power Coop., and Corn Belt Power Coop.	1973
Louisiana:				
Waterford Generating Station				
Unit 3 (Taft)		1,165	Louisiana Power & Light Co	1976
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)	+	654	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)				
Unit 1	●	61	Power Reactor Development Co.	1963
Unit 2		1,123	Detroit Edison Co	1973
Midland Nuclear Power Plant (Midland).				
Unit 1		[2] 492	Consumers Power Co. of Michigan.	1974
Unit 2		[2] 818	do	1975
Palisades Plant (South Haven)	+	700	do	1971

See footnotes at end of table.

TABLE I.—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Con.

Plant (site)	Operable ● Const. auth. +	Capacity (net Mwe.)[1]	Utility/owner	Startup
Minnesota:				
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 (Brownsville).	+	778	Nebraska Public Power Dist	1971
Fort Calhoun Station (Ft. Calhoun)				
Unit 1	+	457	Omaha Public Power Dist	1972
New Jersey:				
Oyster Creek Nuclear Power Plant (Toms River)				
Unit 1	●	560	Jersey Central Power & Light Co.	1969
Forked River Nuclear Generating Station (Forked River).				
Unit 1		1,140	do [3]	1975
Salem Nuclear Generating Station (Salem).				
Unit 1	+	1,050	Public Service Electric & Gas Co., Philadelphia Elec. Co., ACEC, & Delmarva P&L.	1972
Unit 2	+	1,050	do	1973
Newbold Island Nuclear Generating Station (Newbold Island)				
Unit 1		1,088	Public Service Electric & Gas Co.	1974
Unit 2		1,088	do	1976
New York:				
Bell Station (Lansing)		838	New York State Electric & Gas Corp.	[4]
Indian Point Station (Buchanan)				
Unit 1	●	265	Consolidated Edison Co	1962
Unit 2	+	873	do	1971
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 (Brookhaven).		819	Long Island Lighting Co	1975
Verplanck, Unit 1		1,115	Consolidated Edison Co	1977
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	1975
Unit 2	+	821	do	1973
Unnamed (site not announced)		821	do	[5]
William B. McGuire Nuclear Station (Cowans Ford Dam)				
Unit 1		1,150	Duke Power Co	1975
Unit 2		1,150	do	1976

See footnotes at end of table.

TABLE 1.—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Con.

Plant (site)	Operable ● Const. auth. +	Capacity (net Mwe.)[1]	Utility/owner	Startup
Ohio:				
Davis-Besse Nuclear Power Station (Oak Harbor).		872	Toledo Edison Co. and Cleveland Electric Illuminating Co.	1974
Wm. H. Zimmer Nuclear Power Station (Moscow)				
Unit 1		810	Cincinnati Gas & Electric Co., Columbia and Southern Ohio Electric Co. and Dayton Power & Light Co.	1974
Oregon:				
Trojan Nuclear Power Plant (Prescott)				
Unit 1		1,130	Portland Gen. Elec. Co	1974
Pennsylvania:				
Beaver Valley Power Station (Shippingport).				
Unit 1	+	847	Duquesne Light Co., Ohio Edison Co., Pennsylvania Power Co.	1972
Peach Bottom Atomic Power Station				
Unit 1	●	40	Philadelphia Elec. Co	1966
Unit 2	+	1,065	Philadelphia Elec. Co., Public Service Elec. & Gas Co., ACEC, & 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	+	810	Metropolitan Edison Co	1972
Unit 2	+	810	Jersey Central Power & Light Co.	1974
Susquehanna Steam Electric Station (Berwick)				
Unit 1		1,052	Pennsylvania Power & Light Co.	1978
Unit 2		1,052	do	1979
Limerick Generating Station (Pottstown)				
Unit 1		1,065	Philadelphia Electric Co	1974
Unit 2		1,065	do	1976
Puerto Rico (Territory of):				
Aguirre Nuclear Power Plant (Aguirre Bay).		583	Puerto Rico Water Resources Authority.	1975
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	1971
Unit 2	+	886	do	1972
Unit 3	+	886	do	1973

See footnotes at end of table.

TABLE 1.—CENTRAL STATION NUCLEAR POWERPLANTS* UNDER CONTRACT—Con.

Plant (site)	Operable ● Const. auth. +	Capacity (net Mwe.)[1]	Utility/owner	Startup
Tennessee:				
Sequoyah Nuclear Power Plant (Daisy).				
Unit 1	+	1,124	TVA	1973
Unit 2	+	1,124	do	1974
Watts Bar Nuclear Plant (Watts Bar Dam).				
Unit 1		1,170	do	1976
Unit 2		1,170	do	1976
Unnamed (site not announced)				
Unit 1		1,201	do	1977
Unit 2		1,201	do	1977
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.	1973
Unit 2		845	do	1974
Surry Power Station (Gravel Neck)				
Unit 1	+	780	do	1971
Unit 2	+	780	do	1972
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. & Wis.-Mich. Power Co.	1970
Unit 2	+	497	do	1971

*Operable plants are indicated by a dot (●), those listed as "construction authorized" with a plus (+) symbol, are the ones for which an AEC construction permit has been issued, and those without a symbol have not received a construction permit. Excluded from this list are the small Hallam Nuclear Power Facility (Neb.) Elk River Nuclear Plant (Minn.), Piqua Nuclear Power Facility (Ohio), Pathfinder Atomic Power Plant (S.D.), Carolinas-Virginia Tube Reactor (S.C.), and the Boiling Nuclear Superheater (BONUS) Power Station (P.R.) all small prototype plants which have been closed down. Listing also does not include the Nation's only 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 in the "N" reactor started in 1964 (the reactor had achieved initial criticality on Dec. 31, 1963); electricity generation began on Apr. 8, 1966.

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

[2] 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.

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

[4] Utility announced indefinite postponement.

[5] No announced date.

NUCLEAR INDUSTRY GROWTH

The growth of orders for reactors for nuclear powerplants in 1970 provided new evidence of the strength of the underlying forces sustaining the growth of the nuclear industry as a whole and points toward the 70's as a decade of unprecedented growth.[2] The Atomic Industrial Forum noted at midyear: "The 60's were years of research, development, and the formation of new enterprise. The 70's will witness this new industry's growth to a multi-billion-dollar-business."

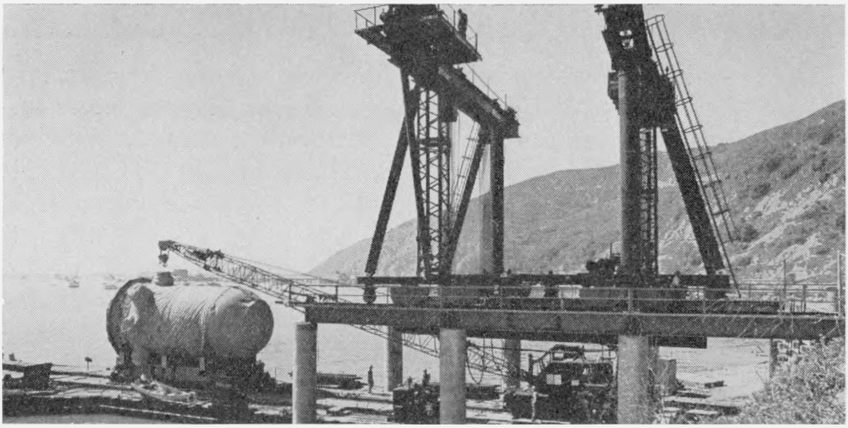
GROWTH INDICATORS

At yearend, with some 108 nuclear central station electric generating units with a total electrical capacity of over 86,000 megawatts in operation, under construction, or on order, the nuclear capacity was approaching the Nation's total capacity of less than a quarter-century ago. The capacity of the whole U.S. network was about 95,000 Mwe. in 1950—7 years before the first nuclear demonstration central station plant began operation at Shippingport, Pa. During 1970, two large utilities—Duke Power Co. and Southern California Edison—publicly announced they foresee only nuclear plants being added to their systems; however, the Southern California Edison statement indicated this was only for the Los Angeles "air basin" at this time. In the Pacific Northwest area, where a power shortage is foreseen, plans were underway to create a "nuclear park," with possibly as many as eight nuclear powerplants, near Richland, Wash. The idea gained impetus during October when the Washington Public Power Supply System (WPPSS) announced plans to locate a 1,100-Mwe. nuclear plant there instead of at a coastal site; the contract for the plant is expected to be let by mid-1971.

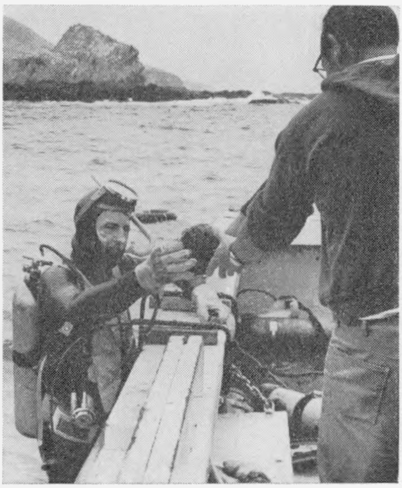
Industrial Expansion

Orders for nuclear electric generating plants, and for the fuel for plants, along with the prospects for a continuing expansion in nuclear power, have resulted in new production facilities or the expansion of existing facilities at some 40 locations in 16 states. These include new ore concentrating mills in Texas, Utah and Wyoming; new nuclear powerplant component manufacturing facilities in North and South

[2] For a complete report on the atomic energy industry, see "The Nuclear Industry—1970," 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 $2.75.



The Reactor Containment Vessel for Diablo Canyon's Unit 1 was brought ashore (*above*) at a special barge landing site near Avila Beach, Calif., on September 17, 1970, after a barge-ship-barge trip had brought it from Chattanooga, Tenn. Built by Combustion Engineering for the Pacific Gas & Electric Co., the 345-ton vessel was barged down the Tennessee, Ohio, and Mississippi Rivers to New Orleans where it was loaded aboard a ship. After passing through the Panama Canal, the reactor component was again transshipped at San Francisco for a barge trip back down the coast to Avila Beach. For the last 7 miles, from the beach to the Diablo Canyon site, the vessel was aboard a 192-wheeled trailer. While work progressed at the plant site, the PG&E sponsored a massive transplant of some 14,000 abalone which abound off San Luis Obispo County's coast. The mollusks, considered a seafood delicacy by many, were endangered by a breakwater being constructed to protect the cooling water intake for the nuclear powerplant. The transplanting was carried out by commercial abalone divers (*below*) under supervision of the California State Department of Fish and Game. The commercial fishermen voluntarily relocated many of the abalones off Montana de Oro State Park where they will be accessible to sport divers working from shore. The Westinghouse-built, 1,060-Mwe. pressurized water reactor is scheduled for 1972 operation; a twin unit, for which the PG&E received an AEC construction permit in December, has a planned 1973 operational date.



Carolina, Florida, Tennessee, Pennsylvania, and Ohio, and new nuclear fuel processing and fabricating facilities in North and South Carolina, Tennessee, Oklahoma, Missouri, Pennsylvania, Illinois, New York, Washington, and Connecticut. Although the individual companies carrying out these expansions have not all published data on the costs involved, from published information available, it is estimated that the total investment in these new facilities is about $750 million. It is also estimated that employment in these new plants will approach 10,000 people.

There is every indication that, by the end of 1980, some 150,000 Mw. of nuclear capacity will be in operation providing nearly 25 percent of total U.S. electricity needs. At current prices, the nuclear plants now ordered represent a commitment by industry for plants and nuclear fuel over a 30-year operating period of about $80 billion.

Other indications of sustained economic growth of the private nuclear industry include:

- An increase in shipments of nuclear products in 1969,[3] as reported by the Bureau of the Census, of about 14 percent. This continues a trend begun in 1966. Shipments in 1969 were more than 2½ times the shipments reported for 1965.
- Sales of radioisotopes for medical purposes appear to be expanding at about 25 percent annually and seem likely to continue at this rate well into the future. Sales of radioisotopes for other uses, and sales of products produced or enhanced through the use of ionizing radiation, also continued to expand but at a more modest rate.
- Encouraging results of experimental work in the peaceful applications of nuclear explosives give promise of increasing the recoverable reserves of natural gas.
- Prospective shortages in availability and recent increases in prices of fossil fuels have emphasized the importance of nuclear energy in meeting total energy requirements in the years ahead.

Cooperation With Industry

Since the beginning of the U.S. atomic energy program, Government and industry have worked cooperatively to advance all uses of nuclear energy. The AEC's first plants and laboratories were constructed and operated by independent industrial and educational organizations in order to take full advantage of industrial skill, experience, and initiative.

In drafting the original Atomic Energy Act of 1946 and in its

[3] Latest available figures; U.S. Bureau of Census data for 1970 will not be available until about mid-1971.

comprehensive 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 the AEC and the Congressional Joint Committee on Atomic Energy to encourage broad industrial participation have contributed much to 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 nuclear industry, the AEC has found it essential to maintain continued communications with industrial associations and with industry leaders. This is accomplished through frequent meetings between the AEC and industry groups. An important channel of communication between the AEC and the nuclear industry is the Atomic Industrial Forum (AIF). Frequent meetings by the Commissioners with the AIF provide for a free and informative exchange of views on matters of mutual interest and concern. Other associations also providing important channels of communication between AEC and industry include such diverse groups as the American Public Power Association and the Manufacturing Chemists' Association. Representatives of several groups met with individual Commissioners and members of the AEC staff during 1970.

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. The creation of and subsequent membership in a compact in no way impinges on the individual State's rights with regard to nuclear matters; no authority or jurisdiction vested in a member State is surrendered to a compact or the Federal Government. The compact provides a vehicle through which the States can advance their participation in nuclear technology and exercise their authority with increased knowledge and vision thus facilitating the working relationships necessary to the transition from the realm of pure science to the democratic process of State government action.

During 1970, one new regional (western) compact came into formal being, and steps leading to another, in the midwest, continued to advance; the original compact group (southern) not only continued to work closely with the AEC but aided in the promotion of other regional compacts.

Southern Interstate Nuclear Board

The Southern Interstate Nuclear Board was established in 1961 following ratification of the Southern Interstate Nuclear Compact.[4] It has fostered State and regional cooperation among educational institutions, industry, and Government to meet opportunities and responsibilities inherent in the expansion of nuclear technology and the growing peaceful applications of nuclear energy.

An important activity of the SINB during 1970 was the provision of financial, secretarial, and administrative support to a task force of the Southern Governors' Conference on Nuclear Power Policy. The task force was created to investigate the public issues, opportunities, and environmental effects related to the increased use of nuclear power and to assist in the development of State and regional nuclear power policies which would be in the public interest. The report[5] of the task force, a valuable reference document for State officials concerned with electric power development, was presented to the Southern Governors at their annual meeting in September 1970.

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, appointed by the President of the United States and reporting to him through the Chairman of the AEC.

During 1970, the SINB sponsored symposiums on space applications of nuclear technology, nuclear developments as they affect State and local officials, and education and research in the nuclear fuel cycle. The SINB also has underway: A study on the feasibility of a nuclear-agro-industrial complex in the region; a survey of nuclear faculty and facilities of southern schools looking toward a cooperative sharing program; and (in cooperation with the National Science Foundation) a research and planning project to develop recommended science and technology policy and strategy for stimulating regional development.

Western Interstate Nuclear Board

Eleven Western States[6] are active members of the Western Interstate Nuclear Board (WINB) and congressional legislation approving the

[4] An agreement among 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. Puerto Rico became an affiliate member during 1970. Affiliate membership has been offered to the Virgin Islands. SINB headquarters are at 800 Peachtree St. NE., Atlanta, Ga. 30308.

[5] Available from the Southern Interstate Nuclear Board, Suite 664, 800 Peachtree Street NE., Atlanta, Ga. 30308; price: $5 per copy.

[6] The States of the Western Governors' Conference are: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. All except Hawaii and Montana have approved the compact.

412–406—71——4

compact was passed in October 1970 and signed by the President. An executive director of the compact has been selected[7] and a headquarters established in Denver, Colo.[8] Three major areas selected by the board for initial study projects are: Radioactive waste management in the West, the Plowshare program as it may affect Western State governments, and a meeting for the exchange of information on powerplant siting problems in the Western States.

Midwest Interstate Nuclear Compact

A nuclear compact among the States of the Midwest Governors' Conference[9] was endorsed by the Governors in 1966. Since then, enabling legislation has been prepared for consideration by the individual States and has been passed by Illinois. In October 1970, a compact conference was held in Chicago sponsored by the Illinois Legislative Commission on Atomic Energy. The purpose of the conference was to encourage legislative action by the other Midwestern States. State and Federal officials, including representatives of the Southern and Western Interstate Nuclear Boards, addressed the group. Enabling legislation by the individual States which would permit the organizing of a Midwest Nuclear Compact is anticipated.

---

[7] Dr. Alfred T. Whatley, a native of California with a doctorate from Princeton University and broad experience in space applications of nuclear science.

[8] The WINB mail address is: P.O. Box 15509, Lakewood, Colo. 80215.

[9] Representing: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin.

Chapter 2

ENVIRONMENTAL AND SAFETY ASPECTS

A subject which captured much of the attention of the American people and their government during 1970 was that of the environment. President Nixon set the tone in his State of the Union address when he declared: "The great question of the seventies is, shall we surrender to our surroundings, or shall we make our peace with nature and begin to make reparations for the damage we have done to our air, to our land, and to our water?"

NATIONAL ENVIRONMENTAL POLICY

The Federal Government's response to the challenge came in the form of new programs, new laws, new agencies—all designed to focus available resources and talent on solving the most pressing of the Nation's environmental problems.

To provide for a more orderly and systematic organization of environmental programs, the President established two new agencies: The Environmental Protection Agency (EPA), and the National Oceanic and Atmospheric Administration (NOAA).

In the Congress, laws were enacted which called for stricter controls over air and water quality. Two of these laws have had a significant impact on the AEC and its activities.

On January 1, 1970, the President signed the National Environmental Policy Act, which broadly outlines agency responsibilities. Upon enactment, Congress stated that the purposes are: "To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere, and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality."

The second significant piece of legislation was the Water Quality Improvement Act, which served to strengthen existing laws against water pollution by requiring applicants for a Federal license or permit to certify that the activity will be conducted in a manner which will not violate applicable water quality standards. This certification is to be issued by the appropriate State or Federal water pollution control agency, or the Administrator of the EPA.

State and Local Actions

At the State level, Governors and legislatures took action to improve and maintain environmental quality. Several legislatures held hearings and enacted legislation to control various environmental hazards.

Finally, the national concern was reflected quite vividly at the local level where citizen participation provided strong impetus for enact-

A Smoggy Morning in the Downtown Area of Chicago, such as shown *above,* may someday be a thing of the past as the result of cooperative work being done by the AEC's Argonne National Laboratory, the city of Chicago, and the U.S. Department of Health, Education, and Welfare. The smoke, on this otherwise clear day, is being generated by industry upwind of the city and held close to the surface of the earth by a temperature inversion. A statistical model developed by Argonne can predict severe pollution conditions such as this in advance, enabling industry to convert to smokeless fuels thus alleviating the hazardous pollution of sulfur dioxide (SO_2) that builds up in the form of a haze.

ment of laws to prevent the dumping of untreated sewage into waterways, protest the proposed location of powerplants, demand the use of the latest equipment to reduce air pollution and, in general, affirm the importance of environmental values where these values seem to conflict with other needs.

With respect to AEC activities, citizen participation in the discussions regarding increased electric generating capacity pointed quite clearly to a need for greater public understanding of nuclear power and the role it should play in the technological-environmental crisis.

A significant proportion of the AEC's effort during 1970 was directed toward improving the quality of the environment. Through new research projects, development of procedures to implement environmental legislation, increased cooperation with other agencies and greater efforts to inform the public, the AEC fully committed itself to the nationwide effort which, hopefully, will prevent further environmental deterioration and give assurance of a higher quality of life for all citizens.

Congressional Public Hearings

During 1970, a considerable effort was made by the AEC, the Congress, the nuclear industry, and the academic community to place the facts on the environmental effects of nuclear power production before the American public.

JCAE Environmental Hearings

In February, the congressional Joint Committee on Atomic Energy (JCAE) completed the second phase of its public hearings on the environmental effects of electric power generation from all sources. The first phase, conducted in the fall of 1969,[1] received testimony from representatives of Federal agencies having responsibilities in the fields of air and water quality and other environmental factors associated with electric power stations. The second phase covered testimony from representatives of State governments, industry, environmental groups, and the general public.[2]

---

[1] See pp. 117–118 "Annual Report to Congress for 1969."

[2] "Selected Materials on Environmental Effects of Producing Electric Power" JCAE, Congress of the United States, August 1969, price $2.50; "Environmental Effects of Producing Electric Power," (Oct. 28 to Nov. 7, 1969) part 1, $4.50; "Environmental Effects of Producing Electric Power" (Jan. 27 to Feb. 26, 1970) part 2 (vol. I), $3.25; and "Environmental Effects of Producing Electric Power" (Jan. 27 to Feb. 26, 1970) part 2 (vol. II), $3.50. Vol. II contains a hearings index and selected materials. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at the indicated prices.

In addition to the JCAE hearings, the AEC provided testimony at hearings held by other congressional committees throughout the year.

Numerous requests were received by the AEC to present the facts on environmental effects of nuclear power generation before public meetings, city and State legislative hearings, adult education forums, scientific and professional groups, and university-sponsored symposia. AEC Commissioners and key senior staff devoted considerable attention to these efforts, so that the public could be provided information on which to base its decisions concerning alternative forms of power generation.

AEC ENVIRONMENTAL PROGRAMS

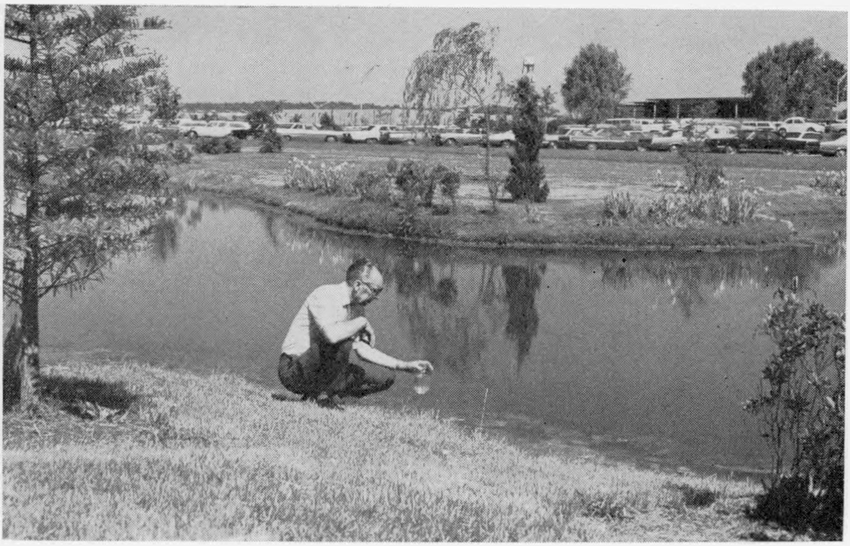
The AEC possesses the capability of bringing a broad range of scientific and engineering talent to bear on national problems which warrant urgent attention. This capability exists by virtue of the unique chain of historic events that made it necessary for the AEC to develop the competence to translate advanced scientific theory and concepts into a safe technology and reliable facilities. This responsibility, which was initially concentrated on military applications, has been greatly amplified in response to the challenge of employing the atomic nucleus for peaceful purposes.

A primary objective of the AEC, from its inception, has been to conduct its activities in a manner which would provide for the protection of environmental values. In this effort, the AEC has worked closely with other Federal and State agencies.

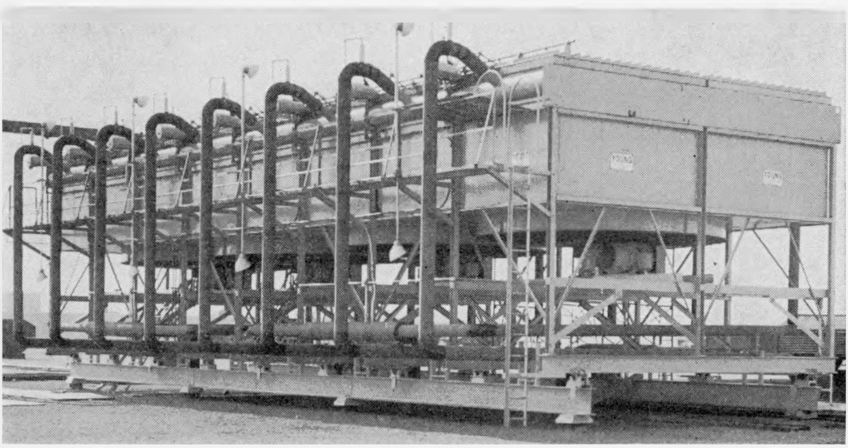
Interagency Cooperation

The AEC cooperates with other Federal agencies in matters of common environmental interest through studies conducted at its multipurpose laboratories.[3] A 1967 amendment to the Atomic Energy Act of 1954 gives the AEC specific authority to conduct research for other agencies at an AEC laboratory in the field of public health and safety, including the environment. The AEC's contractor-operated laboratories are currently carrying out 50 such projects for other agencies in environmental and health-related research. In addition, the AEC has entered into 40 or more agreements with other agencies for work related to the study or monitoring of the environment. One such is the Southwestern Radiological Health Laboratory of the Environmental Health Service, EPA (formerly under the Public Health Service)

[3] See Appendix 3.



Although Air and Water Pollution Abatement at Government installations is now required by Presidential Executive order, the AEC, because of the hazardous nature of the materials with which it works, has long made pollution abatement a major factor in its operations. In the photo *above*, a water sample is being taken from a pond near the Oak Ridge (Tenn.) Gaseous Diffusion Plant to check the sediment for potential accumulation and reconcentration of contaminants. Photo *below*, is of a prototype air-cooled condenser now undergoing tests at the Portsmouth (Ohio) Gaseous Diffusion Plant. A potential cost-saver in pollution control, the air-cooled condenser, being developed by Goodyear Atomic Corp., has an operating cost which is one-tenth of that for existing water-cooled condensers.



which annually provides about $1.8 million in technical services related to activities at the AEC's Nevada Test Site (see "AEC Operational Safety Aspects" section near end of this chapter). Similar agreements exist with subagencies of the National Oceanic and Atmospheric Administration (NOAA), and with the U.S. Geological Survey and other agencies.

Underground Nuclear Testing

Along with the growing concern for the environment, there have been an increasing number of indications of public uneasiness about nuclear testing and particularly about high-yield nuclear testing and Plowshare excavation experiments. Because these matters had become worrisome to the public, a considerable bioenvironmental study program has grown up in the past years and this program was intensified during 1970.

Changes were initiated within the Executive Branch of the Government so that all of the AEC's plans for nuclear testing are reviewed by the undersecretaries committee of the National Security Council and by the Council on Environmental Quality in compliance with the National Environmental Policy Act of 1969. In these ways, the President can be assured that the AEC's plans are being scrutinized carefully before being approved.

During the 1970 underground testing, there were two accidental leakages of radioactivity of sufficient quantity to have been detected off-site. One of these, Baneberry, resulted in low-level radiation exposure to some on-site workers and to a few individuals living nearby off-site. (See "AEC Operational Safety Aspects" section near end of this chapter for results of the 1970 radiological monitoring program).

Interagency Power Plant Siting Group

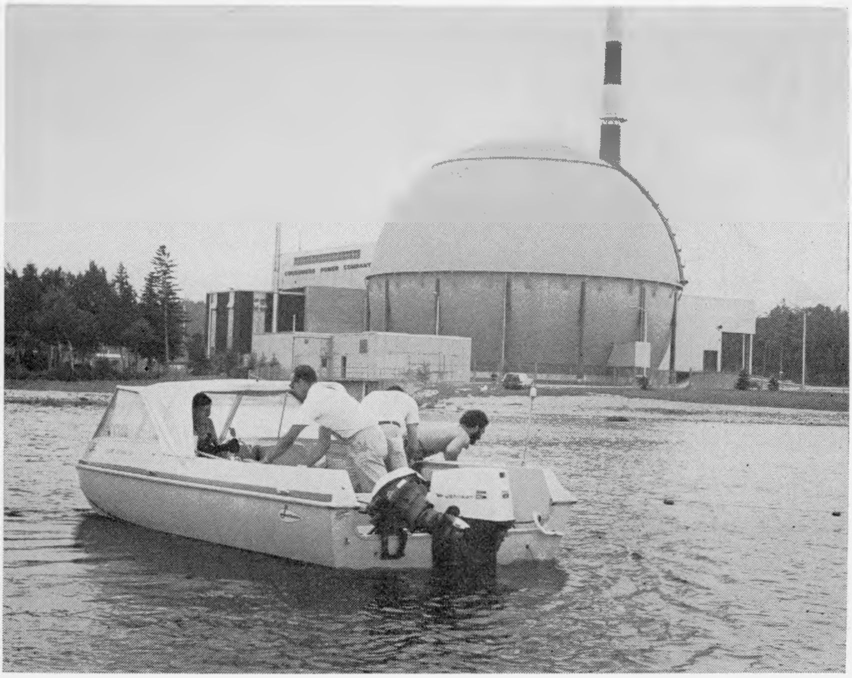
The AEC has been an active participant in the Intergency Power Plant Siting Group since its inception in 1968. Other Federal participants are: Tennessee Valley Authority (TVA), the Department of Health, Education, and Welfare (DHEW), the Department of the Interior, and the Federal Power Commission (FPC). Some of the conclusions of the working group have been published.[4] The AEC was assigned the task of identifying specific research and develop-

[4] "Electric Power and the Environment" a report issued by the President's Office of Science and Technology; Chapter 6, "Research and Development to Alleviate Problems of Powerplant Siting" discusses the various siting issues and suggests institutional arrangements for meeting the Nation's needs for economic electric power with minimum environmental impact. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 at 75 cents.

ment activities that would contribute to evaluating the environmental problems of siting electric plants. Placement and operation of such facilities, as in the case of nuclear powerplants, require knowledge of the local soil characteristics, rock formation, seismicity, water flow and drainage, transmission requirements, land-use plans, and the local weather—including the effects of temperature change on bodies of water at the proposed site.

OST Thermal Effects Study

Coordination of the AEC's thermal effects program with other agency efforts is being achieved, in part, through the AEC's strong participation in the activities of the President's Office of Science and Technology (OST). The OST committee on water resources research has set



The effect of Nuclear Powerplants on a Lake's Ecology is being determined by an Argonne National Laboratory research team. Photo shows fish being netted in Lake Michigan, just off the Big Rock Point (Mich.) Nuclear Power Plant, for laboratory analysis. The fish tissue is vacuum dried as the first step in reducing it to a small laboratory sample. The specimen is then irradiated in a reactor and checked for metallic element content by neutron activation analysis. The results of a number of such checks can be used to provide a general picture of concentration and location of pollutants. The Big Rock Point plant has been in operation since 1962 and thus provides a good study area for long-term ecology studies.

up an interagency task group on the "Effects and Control of Heater Water Discharges." All interested Federal agencies are represented on the task group. The task group, which is chaired by a representative of the AEC, will publish a report on its findings on thermal effects in the near future.

Organizational Changes

In keeping with its long-standing concern for environmental values, a substantial proportion of the AEC's offices and divisions have detailed responsibilities relating to environmental matters. Most of these have special facilities under their direct charge or within their administrative purview. In recognition of the need for greater coordination in environmental programs, several actions were taken during the past year.

At midyear, the AEC announced the establishment of two new staff groups: (*a*) An Office of Environmental Affairs; and (*b*) a Division of Waste and Scrap Management. The move was part of the AEC's continuing efforts to insure that its operations are responsive to the environmental challenges and to assure protection of the environment.

New Environmental Legislation

The AEC has had no regulatory authority, under the Atomic Energy Act, over environmental matters other than radiological health and safety considerations. However, under recently enacted laws, certain AEC regulatory actions (such as power reactor licensing) have become check points for conformity to environmental quality standards. (See also Chapter 3 on regulatory actions and policy statement.)

Policy Acts and Executive Orders

The National Environmental Policy Act of 1969 (NEPA) became effective on January 1, 1970. It requires Federal agencies to prepare statements on major actions significantly affecting the quality of the environment. It set in motion an excellent means by which the public interest in the safety of AEC activities could be satisfied in an orderly fashion. Under the law, the AEC will broaden its procedures of in-inviting Federal agency comments on environmental questions and giving State and local agencies an opportunity for comment.

On December 4, 1970, the AEC issued a revised policy statement on implementation of NEPA in its licensing of nuclear powerplants, which will provide for fuller consideration of environmental issues during licensing proceedings (see Chapter 3).

Executive Orders. To provide specific guidance to Federal agencies on procedures to be followed, the President issued an Executive Order which requires all Federal agencies to "initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals." An additional Executive Order on "Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities" directs Federal agencies to provide leadership in this nationwide effort by designing, operating, and maintaining their own facilities in such a way as to protect and enhance air and water quality. The latter Executive Order and its predecessors, governing the control of air and water pollution from Federally owned facilities, require Federal agencies to develop plans for upgrading existing facilities to comply with applicable air and water quality standards by the end of 1972. Thus far, a total of 71 projects have been included in AEC's air and water pollution abatement plans at an estimated cost of nearly $9 million. Forty-five of these projects are either completed, nearing completion, or otherwise achieving compliance with standards, and six are newly proposed projects as a result of recently completed studies, operational changes, or impending changes in standards. The remaining projects are in varying stages of study, planning and design.

FRC Abolished. The new Environmental Protection Agency (EPA) acquired all functions of the former Presidential advisory body, the Federal Radiation Council (FRC). Since 1959, the FRC had provided official guidance to Federal agencies in the form of radiation protection guides for atomic industry employees and the general public. FRC guidance applied to all sources of exposure from normal peacetime operations except natural background radiation, and medical or dental radiation (X-rays).

Henceforth, the AEC and other Federal agencies will be guided by environmental radiation standards established by EPA.

ENVIRONMENTAL EFFECTS

In considering the environmental effects of nuclear power applications three areas receive special attention: Radioactivity, thermal effects, and disposal of high-level waste. Through the years, the AEC's considerable research effort in these areas have resulted in improved operating techniques. Emphasis has always been put on lessening undesirable effects.

Radioactivity

One of the few environmental stresses that may be measured, both in terms of delivery and effect, is radiation.

Standards and Guidance

In this area, one peculiar to its mission, the AEC has had the benefit of the pooling of expertise through independent national and international bodies which recommend radiation protection standards. Among these are the National Council on Radiation Protection and Measurements (NCRP), the National Academy of Sciences-National Research Council (NAS–NRC), and various Federal agencies. On the international level, groups such as the International Commission on Radiological Protection (ICRP) and the U.N. Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have maintained an active role in radiation protection and have provided recommendations on the setting of radiation protection standards.[5] They draw upon the scientific community for individuals who have specific knowledge in areas of direct concern. Hence, greater expertise than might be available in Federal agencies is brought to bear. Such groups have been extremely helpful in pointing out areas requiring additional research.

During 1970, a number of questions were raised regarding the adequacy of radiation protection standards. In order to provide for a thorough analysis of these questions, the National Academy of Sciences was asked to undertake a complete review of all available scientific data and to recommend changes it deems necessary. This review is expected to require 2 years for completion.

Radiation in Perspective

In considering the standards for releases of radioactivity from nuclear power operations, it is important to understand that these small amounts represent only a fraction of the total radioactivity man receives from a variety of sources. The table helps to provide a better perspective:

---

[5] ICRP reports are available from Pergamon Publishing Co., Fairview Park, Elmsford, N.Y. 10523; NCRP materials are available from NCRP Publications, P.O. Box 4867, Washington, D.C. 20008; and UNSCEAR reports are available through the U.N. Publications Office, U.N. Headquarters, New York City 10017.

APPROXIMATE CURRENT ANNUAL AVERAGE DOSES FROM IONIZING RADIATIONS

Source	Approximate annual average dose (mR)	Approximate percentage of natural background
1. Natural background [1]	125	
2. Manmade sources:		
(a) Medical uses	55	45
(b) Weapons testing [2]	1	1
(c) Nuclear power and fuel reprocessing plants	<1	<1

[1] Includes sources such as cosmic and terrestrial radiations and natural occurring radioactive elements in the body.
[2] This does not include a 9.0 mR dose to the bone from strontium-90 which is not additive to the other doses in this table, and which is less than 1 percent of radiation protection guidelines for bone dose.

The radiation that might be received from the effluent of a nuclear powerplant must also be placed in perspective. Experience over many years has shown that the radiation a person might receive by living near a typical operating nuclear powerplant for a year would be a small fraction of the radiation that would normally be received in a year from natural sources. The increased exposure would, very likely, not be as great as could be obtained from moving to a new location or taking a transcontinental high-altitude flight.

PHS Supports Reactor Safety Aspects

During the fall of 1970, the PHS published [6] a study on the Dresden, Ill., nuclear reactor which concluded: "On the basis of these measurements, exposure to the surrounding population through consumption of food and water from radionuclides released at Dresden was not measurable. External exposure from radioactive gases discharged from the Dresden stack was detectable, but it was only a small fraction of the natural radiation background over an extended period of time, and well within radiological protection guidance."

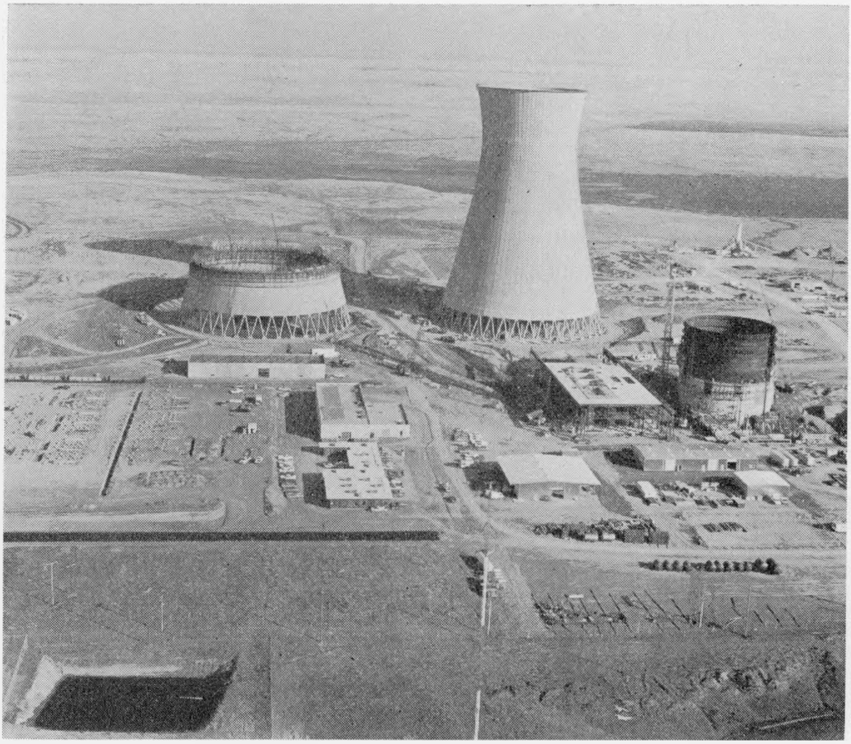
Thermal Effects

All steam-generating electric plants, nuclear and fossil-fueled, discharge waste heat to the environment.

[6] "Radiological Surveillance Studies at a Boiling Water Nuclear Power Reactor," available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151, $3 a copy.

Waste Heat From Reactors

Large quantities of water are necessary in the operation of steam plants for removing the heat remaining in the steam exhausted from the turbine to the condenser. Nuclear plants of current design require about 50 percent more cooling water because their thermal efficiency is lower than that of fossil-fueled plants. This will not be true of future reactors of advanced design, which will be comparable to fossil-fired plants in the use of coolant water.



Cooling Towers under Construction at the Rancho Seco Nuclear Generating Station of the Sacramento Municipal Utility District. The photograph shows the reactor containment shell at the right with a 425-foot-high cooling tower, which will be used to cool water flowing at the rate of 500 gallons per minute, nearing completion to its left and the base of another tower just "getting off the ground." Nuclear plants of modern design require 50 percent more cooling water than fossil-fired plants to keep within the same temperature rise. When evaporative or nonevaporative cooling towers, spray ponds, or other cooling methods are used, cooling water requirements are greatly reduced. The Rancho Seco Station, near Ione, Calif., is one of more than a dozen nuclear powerplants which will use cooling towers.

The volume of water required for cooling is dependent upon the heat rise that can be permitted in the water as it passes through the condenser. This is controlled by the effect on the receiving waters. Hot water cannot retain as much dissolved oxygen as can cooler water and therefore it will adversely affect aquatic plants and animals. The problem of estimating the long-term impact of thermal loading on streams used for cooling water by both nuclear and nonnuclear powerplants has become important nationally.

The thermal effects of powerplant operation have not yet constituted a major problem. However, in the future, electric power needs will require the building of an increased number of large plants. AEC is conducting research which will total $3.2 million in fiscal 1971 (which ends June 30, 1971). In addition, other Federal agencies and public utilities are sponsoring research projects which are adding significantly to the total body of knowledge in this area. A new research facility at the AEC's Savannah River Plant is expected to make significant contributions to the solution of the problem.

Radioactive Waste Disposal

In 1970, the AEC announced a significant new policy designed to insure that high-level radioactive waste products are disposed of in such a way that these wastes will not damage the environment. Years of research have proven the feasibility of converting liquid radioactive wastes to solid form which greatly reduces their volume (one hundred gallons can be reduced to 1 cubic foot).

Long-Term Solid Storage

The AEC made a tentative selection in 1970 of a site near Lyons, Kans., for an initial demonstration of long-term storage of solid high-level, and long-lived low-level, radioactive wastes in salt formations.

This demonstration project follows the successful Project Salt Vault which was carried out by the Oak Ridge National Laboratory in a salt mine near Lyons from 1965 to 1967.[7]

Toward the end of 1970, the Committee on Radioactive Waste Management of the National Academy of Sciences (NAS), completed a review of the concept of waste disposal in salt and of the suitability

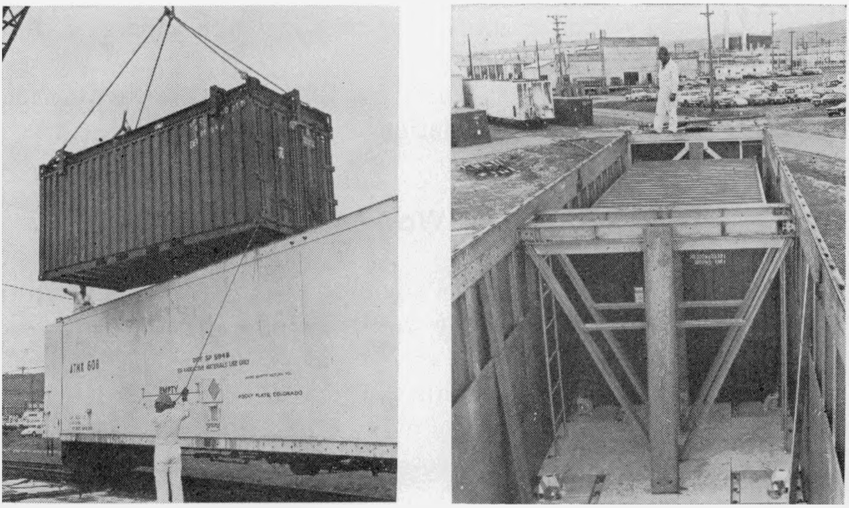
---

[7] See p. 105, "Annual Report to Congress for 1967," and p. 11, "Annual Report to Congress for 1965."

of the Lyons site.[8] The NAS committee report stated that "the use of bedded salt for the disposal of radioactive wastes is satisfactory. In addition, it is the safest choice now available, provided the wastes are in an appropriate form and the salt beds meet the necessary design and geological criteria."

Kaiser Engineers, Oakland, Calif., is working with Oak Ridge National Laboratory (ORNL) on the conceptual design. Geologic and safety studies are also being conducted to confirm that all aspects of the planned operation can be carried out safely. Operation of the

[8] "Disposal of Solid Radioactive Wastes in Bedded Salt Deposits," a 28-page report by the Committee on Radioactive Waste Management of the National Academy of Sciences-National Research Council; copies available for 35 cents each from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.



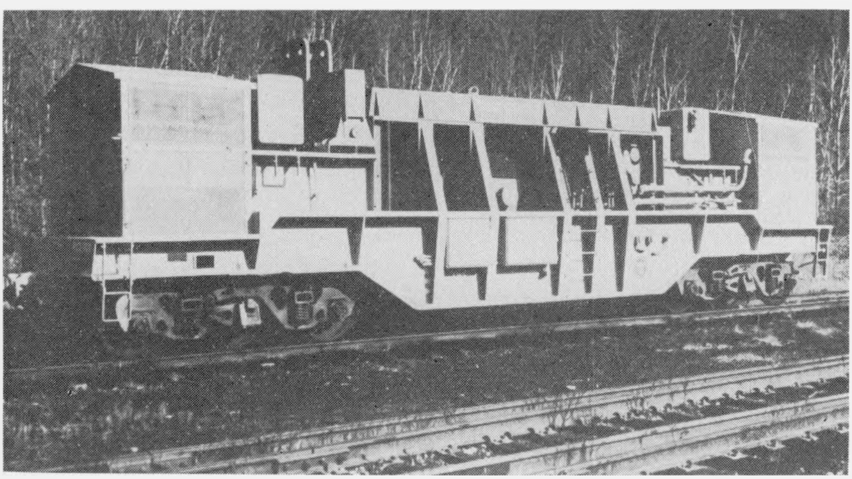
Shipment of Long-Lived, Low-Level Radioactive Wastes to the AEC's proposed repository at Lyons, Kans., would be accomplished by using special railcars which have sealed steel removable containers in which packaged drums of waste are placed. These massive doublewalled steel cars, built at Oak Ridge, Tenn., and owned by the AEC, are currently used for transporting radioactive wastes generated at the AEC's Rocky Flats (Colo.) Plant. At *left* workmen guide a cargo container into one of two bays in the 60-foot long railcar, known as the "ATMX" which has a load capacity of approximately 100,000 pounds. The ATMX car has been designed and constructed to assure that even in the event of a severe accident involving a collision, followed by extensive fire and subsequent immersion in water, the wastes will be safely contained. The elevated view, at *right* shows the structural bracing, floor mounts, and other features of the car's interior. After loading with two 20-foot-long cargo containers the railcar is then fully enclosed with three steel hatch covers prior to transportation. By using heavy, cast-steel underframe and strong superstructure, including cross-bracing of the double-walled sides, the car can structurally withstand severe accidents while safely containing radioactive waste cargo.

low-level waste storage facility is tentatively scheduled for 1975, with high-level facility operation beginning in 1976, subject to Congressional approval.

Waste Storage Facilities

The AEC chemical processing facilities at Hanford, Savannah River, and Idaho concentrate and store highly radioactive waste material in large underground tanks and bins. At Hanford and Savannah River, the liquid wastes are evaporated to concentrated salt solutions which solidify to moist salt cakes as the liquids cool. The Idaho facility uses a high temperature fluidized bed process to convert the liquid wastes to a granular calcined product having about one-ninth the volume of the original solution. The calcined product is transferred to stainless steel bins located in underground concrete vaults.

Surface storage of the concentrated radioactive wastes in liquid form is considered to be an interim measure. Programs to develop methods for the safe long-term containment of the wastes are being conducted



High-Level Solidified Radioactive Wastes will be shipped to the proposed salt mine repository in Lyons, Kans., in containers similar to those already in use in the United States for shipping irradiated fuel from nuclear powerplants to fuel reprocessing plants. Typical of such a container is the shipping cask shown *above* which is owned by Westinghouse Electric Corp. The 75-ton cask, located in the mid-portion of this specially constructed railcar, is surrounded by heavy steel framework. All containers for shipment of radioactive waste must meet rigid, impact, fire, and water immersion tests as specified by the U.S. Department of Transportation which governs such shipments.

412-406—71——5

at Hanford, Savannah River, National Reactor Testing Station, and Oak Ridge National Laboratory.[9]

Hanford Recovery Program

At the Hanford Works, near Richland, Wash., the fission products, cesium-137 and strontium-90 (the principal long-lived isotopes), are being removed from stored and freshly generated highly radioactive wastes to permit these wastes to be immobilized in the waste tanks as soon as possible. The removed cesium and strontium are currently being stored as liquid concentrates in water-cooled stainless steel vessels in concrete cells.

One shipment (approximately 410 kilocuries) of cesium-137 was sent to the ORNL for fabrication into radiation sources to be used in process studies. About 3.2 megacuries of cerium-144, and 54 kilocuries of strontium-90 were supplied in 1970 to the Pacific Northwest Laboratory for highly radioactive waste feed for the AEC's development testing of waste solidification processes.

Idaho Waste Calcining Facility

Modifications to the Waste Calcining Facility at the National Reactor Testing Station in Idaho were completed and calcination of radioactive wastes resumed on August 3, 1970, with a total of 226,000 gallons of liquid radioactive waste being converted to 4,100 cubic feet of granular solids during the year. In the 7 years ending December 1970, the Waste Calcining Facility has solidified 2,060,000 gallons of radioactive waste from the Idaho Chemical Processing Plant operations to 30,100 cubic feet of calcined product. Ion exchange systems have been installed in the Idaho Chemical Processing Plant to treat the waste evaporator condensates increasing the efficiency of radionuclide removal to nearly 99 percent.

Savannah River Waste Storage

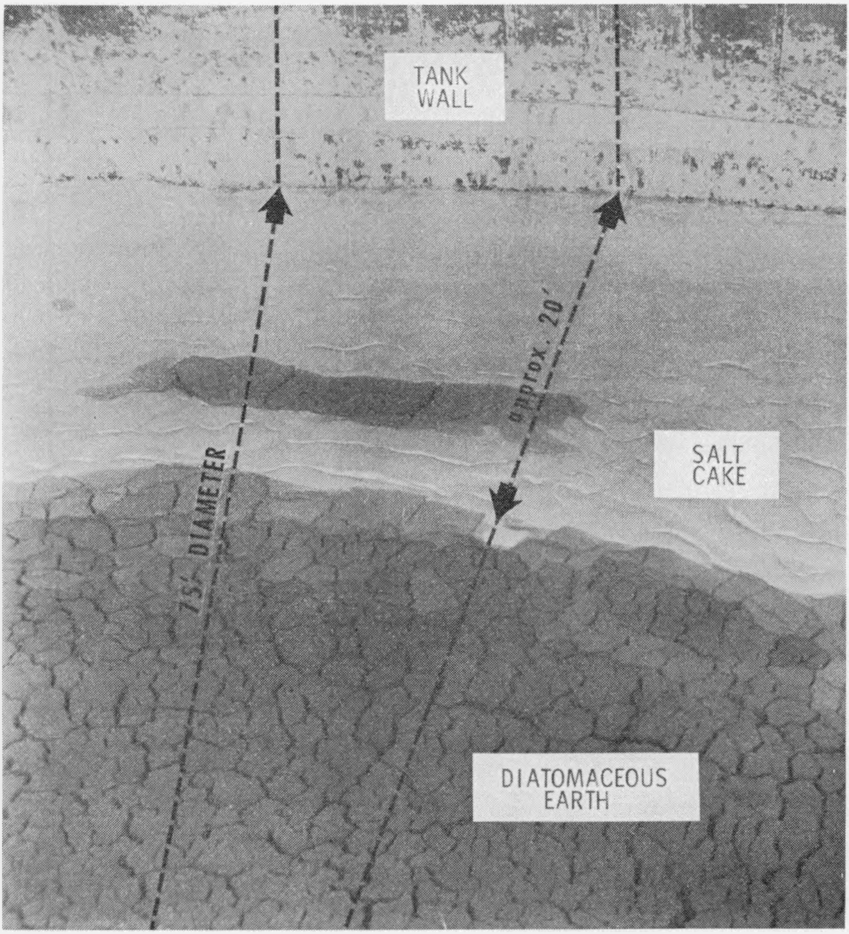
A project to evaluate the integrity of the bedrock[10] under the Savannah River Plant for storing radioactive wastes in caverns excavated in this bedrock was initiated in August 1970. The first phase of this project includes an exploratory drilling program to establish the location of the central shaft (which would provide access

---

[9] See pp. 43–45, "Fundamental Nuclear Energy Research—1968."
[10] See p. 55, "Annual Report to Congress for 1969."

to the bedrock in which the caverns are to be excavated) and preliminary design studies for construction of the shaft and exploratory tunnels into the bedrock.

The proposed exploration program would be the latest in a number of investigations exploring the use of bedrock caverns for storage of high-level radioactive waste.



Converting Liquid Wastes to Salt Cakes at the Hanford Works near Richland, Wash., involves evaporating liquid wastes to very concentrated salt solutions and slurries which solidify as the liquids cool. Shown in the photo *above*, is the interior of a tank used for the in-tank solidification program at Hanford. The view is from the center of the tank toward the tank wall. Diatomaceous earth is added to absorb residual liquid which could not be pumped off. By converting aged liquid wastes to salt cake the danger of wastes escaping is greatly reduced. Fresh liquid wastes are to be stored in double-shelled tanks until the short-lived fission products decay, then these too will be converted to salt cakes.

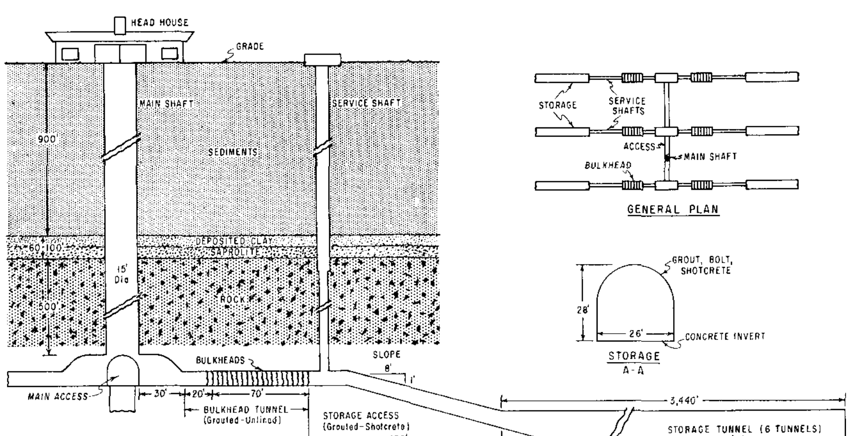
Highly radioactive wastes are currently stored in double containment structures which are underground tanks inside concrete vaults lined with carbon steel. A total of 28 tanks, each having a capacity ranging from 750,000 to 1,300,000 gallons, are now in use. Two new tanks are under construction. All tanks containing the highly radioactive wastes have cooling coils to remove the heat produced as the fission products decay.

ENVIRONMENTAL RESEARCH

The overall objective of AEC's environmental research and development program is to provide knowledge as a basis for greater confidence that nuclear activities may be conducted without harm to man or the environment. In addition to the research studies, the AEC sponsors engineering and instrumentation design efforts which provide assurance that programmatic activities can be, and are being, conducted without disturbing the natural environmental balance and that such disruptions as may occur can be measured, contained, and effectively countered.

AEC-Sponsored Environmental Studies

Among the many research and development projects sponsored by the AEC, over 1,000 are, either directly or indirectly related to radia-



Bedrock Waste Storage Facilities are being investigated for use at the Savannah River Plant for high-level radioactive waste storage. Evaluation of the integrity of caverns excavated in these rock strata was started in 1970. The wastes are a byproduct of the AEC's production and nuclear weapons programs. The diagram shows a cross section view of the bedrock dimensions beneath the Savannah River reservation and the conceptual plan of the storage facility.

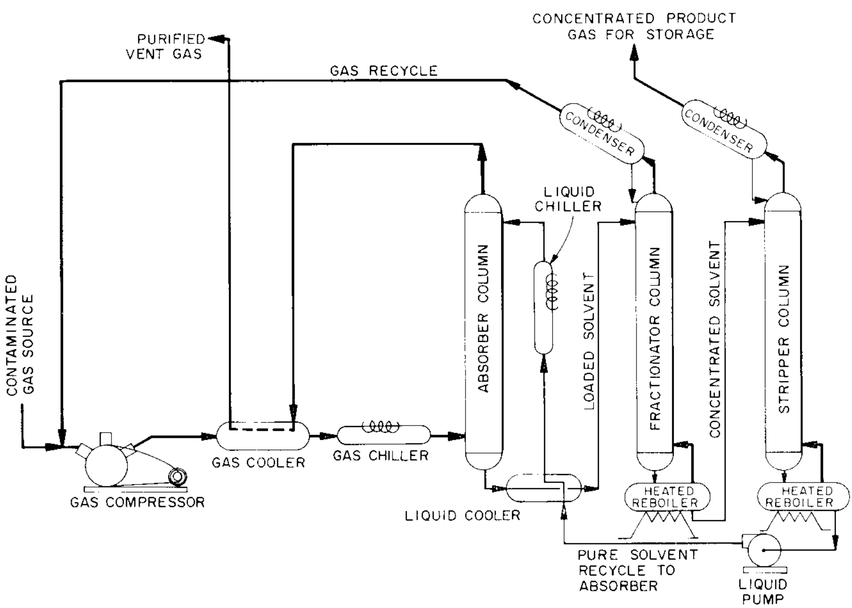
tion effects on the environment.[11] The five major categories of the environmental radiation research program are: (*a*) Transport and fate; (*b*) measuring and monitoring; (*c*) evaluation of effects on natural populations and species; (*d*) prevention and control technology; and (*e*) other biological effects of radiation.

Recent Research Achievements

The AEC environmental aspects section (Part Three) of the supplemental "Fundamental Nuclear Energy Research—1970" report [12] presents noteworthy achievements in environmentally related research and development. The next two pages highlight some achievements.

[11] See "Summaries of U.S. AEC Environmental Research and Development" (TID–4065), containing short notes on each project (166 pp.) ; indexed by contractor, name of principal investigator, and subject of research (116 pp.). Available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151 at $3 a copy.

[12] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.75 a copy.



A Process Which Absorbs Noble Gases (krypton and xenon) into an organic solvent (freon) has reached the pilot plant stage of development at Oak Ridge Gaseous Diffusion Plant. The process is based on previous work performed at the AEC's Brookhaven National Laboratory which showed that these noble gases are more soluble in liquid refrigerant-12 than in other air components (nitrogen, argon, oxygen). Noble gas removal efficiencies of more than 99 percent have been demonstrated by this process. The process resulted from AEC-sponsored research seeking practical ways to reduce further the amount of such gases now released into the atmosphere from some nuclear facilities, even though such releases are now well below prescribed limits.

Gaseous Effluent Control

● The silver form of a synthetic zeolite appears to be a suitable inorganic material to replace charcoal as the iodine adsorbent in reactor atmosphere cleanup systems. It has been shown to be effective as an iodine adsorbent for the effluent gas streams in nuclear fuel processing plants.

Thermal Effects

● The Colheat stream temperature prediction system, originally developed for Columbia River application, has been used to show that a river in Massachusetts and a canal in Nebraska, are capable of accommodating significant increases in the water temperature from powerplant sources, without major effect.

● Fish-tagging experiments have shown that temperature zones in the Columbia River, that are avoided by fish occupy only a small section of the river width and are well below temperatures sufficient to cause death in fish.

Marine and Atmospheric Research

● Neutron activation analysis has shown that Pacific Ocean waters have a significantly higher mercury level than the Atlantic. Since the normal chemical and biological processes of the ocean cannot account for the high mercury values, manmade pollution appears to be the source.

● Atmospheric concentrations of 20 radionuclides appear to be on the rise as a result of continued atmospheric nuclear weapons tests by foreign nations which have not signed the limited nuclear test ban treaty.

Radioactivity in Food Chains

● Some 16 radionuclides have been traced through a simple food web of the Alaskan ecosystem to identify pathways and retention on three successive levels, lichen-caribou-wolf or man. Each successive level discriminated against some radionuclides, and several were concentrated. Many of the radionuclides discriminated against, including natural radium, localize in bone and are effectively removed from man's diet by deposition in animal bone tissue.

● The litter and mosses of conifer forests are not generally palatable to the common large herbivores (elk and deer); therefore, the radio-cesium in such forests does not enter a food chain that leads directly to man.

- Since spiders as predators are often at the top of a food chain, their body burden of cesium-137 is providing valuable clues about the concentration of the radionuclide in the environment and about the interactions of organisms at lower positions in the food chain.
- In two Colorado lakes a decreasing trend of cesium-137 content was noted in lake trout; in a third lake no decrease was found. In this third lake, the principal source of food for the trout was a crustacean; as the fish pursued their prey near the bottom of the lake they also ingested bottom sediment containing cesium-137.
- Kangaroo rats which have lived for several generations near the crater of a thermonuclear excavation in Nevada have heavy body-burdens of tritium. However, no obvious harmful radiation effects have been observed although their DNA cellular radioactivity level was 27 percent higher than the control animals.
- Studies of the concentration of 16 radionuclides in five salmon species ranging between Alaska and central California show that the migratory pattern of the King and Coho salmon may be much more complex than the Alaska salmon.

The Human Food Chain

- Studies of strontium-90 in the human diet in the United States have shown that there is a continued decrease in the amount of radiostrontium in food.
- The annual deposition of fallout cesium-137 from atmospheric nuclear weapons tests in 1961–62 reached a maximum in 1963 and took about 4 years to drop off. The maximum annual dose from cesium-137 occurred in 1964 and amounted to 3 millirads a year, or a few percent of natural background radiation exposure.

Joint Environmental Studies

AEC–PRWRA Cooperative Study

The AEC and the Puerto Rico Water Resources Authority (PRWRA) have initiated joint environmental and ecological studies on the island of Puerto Rico.

The studies will focus on the Bay of Jobos coastal region of southeastern Puerto Rice near Aguirre where PRWRA is constructing two 460-kwe. fossil-fired powerplants and where a 583-Mwe. nuclear powerplant will be located. Long-range plans call for construction there of additional generating units. Work will be performed by the Puerto Rico Nuclear Center (PRNC). The PRNC has been operated for the AEC by the University of Puerto Rico since 1957. In the past 3 years, the PRNC has made extensive studies of Puerto Rico's land and sea environment; previously, in the early 1960's, it had carried out environmental and ecological investigations prior to the building of the experimental Boiling Nuclear Superheat Power Station nuclear powerplant near Rincon.

The AEC participation in the study is part of an expanded effort

The Daily Output of Carbon Dioxide from Forest Floor Litter is measured by the apparatus shown in the photo *above*. The six chambers embedded in the forest floor (*lower left*), contain various combinations of soil litter and organisms. Carbon dioxide, piped from these six "microcosms" to a gas analyzer located on the rack, is measured at 50-minute intervals over a 24-hour cycle by Oak Ridge National Laboratory technical staff.

to gain added information on possible environmental effects of nuclear powerplant operation in view of the rapid growth of the nuclear power industry in this country and abroad. The studies will endeavor to predict the behavior of condenser cooling water that will be discharged. Such information would provide estimates of the pattern and degree of temperature changes in the bay which would be produced by continuous operation of the two steam plants, and any future powerplants constructed there.

Information developed will complement the current nuclear energy study sponsored during the past year by U.S. and Commonwealth agencies, including the AEC and PRWRA.

The PRNC plan, still in a conceptual stage, involves a nuclear energy complex including a nuclear powerplant, a desalting plant, and associated industries and activities requiring large amounts of steam and power.

The new ecological-environmental study at the Bay of Jobos will provide data useful in assessing the potential environmental effects of adding a nuclear energy complex at this location.

Chesapeake Bay Study

During 1970, a multidisciplinary, cooperative study of the problems associated with the siting of nuclear powerplants on the Chesapeake Bay was initiated. It is to: (*a*) Coordinate existing study results which are related to the question of siting nuclear powerplants; and (*b*) provide recommendations for changes of emphasis and acceleration of such studies in order to provide for the most effective use of available resources and technical talent. The following organizations are involved: Atomic Energy Commission; Chesapeake Bay Institute, Johns Hopkins University, Baltimore, Md.; Chesapeake Biological Laboratory, Natural Resources Institute, University of Maryland, Solomons, Md.; Department of Geography and Environmental Engineering, Johns Hopkins University; Virginia Institute of Marine Science, Gloucester Point, Va.; Department of Natural Resources, State of Maryland, Baltimore, Md.; Baltimore Gas & Electric Co., Baltimore, Md.; Potomac Electric Power Co., Washington, D.C.; and Virginia Electric & Power Co., Richmond, Va.

One of the first projects to be carried out under this new cooperative program will be an assessment of present knowledge of the bay and preparation of an overall research program plan for filling in the gaps in this framework of knowledge. The initial phases of the study are focused on the effects of cooling water discharges from powerplants, with other aspects of the total siting problem to be added as the cooperative effort proceeds.

AEC OPERATIONAL SAFETY ASPECTS

In addition to research studies, the AEC sponsors a variety of safety engineering efforts which provide assurance that its programmatic activities can be, and are being, conducted with due regard for public health and safety and without disturbing the natural environmental balance.

AEC SAFETY PROGRAMS

During its existence, the AEC and its operating contractors have maintained an outstanding safety record, not by chance, but by careful

A Pulsed Laser is being used at Oak Ridge National Laboratory to get better understanding of smoke plumes in research on air pollution problems. The Oak Ridge instrument, by means of a telescopic system, is shown aimed at the rising plume (barely visible) from the 800-foot chimney of the TVA's Rull Run Steam Plant. The pulsed beam strikes minute particles in the plume and is reflected back to the instrument's optical system. The weak reflected beam is amplified by a photomultiplier and projected on the screen of an oscilloscope. The oscilloscope pictures are analyzed for data on dispersion and behavior of particles in the plume. The project is being conducted by the Atmospheric Turbulence and Diffusion Laboratory of the National Oceanic and Atmospheric Administration (formerly ESSA) in cooperation with the AEC, TVA, and the new Environmental Protection Agency (EPA).

planning. As a result, the AEC and its contractors have been winners of the National Safety Council's "Award of Honor" a number of times.

Offsite Radiological Monitoring

Offsite radiological monitoring around the Nevada Test Site (NTS), including the Nuclear Rocket Development Station (NRDS) and other test areas (central Nevada, Amchitka Island, Alaska, and at Plowshare program experiments), is conducted for the AEC by the EPA's Environmental Health Service (which took over certain functions previously done by the Public Health Service).

Radiation exposures to the general public at NTS and offsite areas were well below the specified radiation protection guidelines.

During 1970, radioactivity was detected in an unpopulated area near the NTS following two nuclear weapons tests, Snubber on April 21 and Baneberry on December 18. Both inadvertently released radioactivity which could be detected outside the government-controlled area at the Nevada Test Site. Following another test (Mint Leaf, May 5) which had been fully contained, there was a controlled release of radioactivity through a tunnel ventilation system to enable reentry of workers on the day after the test (May 6). This resulted in a single positive air sample from an unpopulated area off-site. Analytical results, including preliminary data from Baneberry, indicate that all radiation exposures to off-site residents from these tests were below established radiation protection guidelines.

Radiation surveillance continued at off-site areas used for two Plowshare events: Project Rulison, detonated in Colorado on September 10, 1969, and Gasbuggy, detonated in New Mexico on December 10, 1967. Reentry operations at the Rulison site began in April 1970 and were completed in September. Production tests and flaring of the gas began in October and are expected to continue intermittently into 1971.

Samples of gas produced from 28 wells surrounding the Gasbuggy project site were collected monthly from November 1969 to November 1970. An automatic sampling system has been installed to continue the surveillance. No radioactivity resulting from the Gasbuggy program has been detected in any of these natural gas samples.

Safety of AEC-Owned Reactors

The AEC headquarters and field safety staffs devoted approximately 40 man-years of effort during 1970 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 (as of

December 31, 1970) of operations that have been free of reactor property loss, 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 from reactors.

The only reactor property loss incident of the year occurred on November 9 at the Savannah River Plant's K-reactor. The incident involved the separation of an antimony-beryllium neutron source rod which failed while it was suspended in air during a reactor charging operation. Failure of the source rod released activity to the process room and to the confinement filter compartments. Activity of 3 millicuries or less was released to the environs; there was no significant personnel exposure. The resultant property loss was large—possibly as much as $800,000—although an accurate figure cannot be obtained until all aspects of the affected operations can be evaluated.

During the year, 24 AEC contractors had operational control over 60 stationary reactors, one nuclear rocket propulsion engine test stand with an associated nuclear rocket test cell, and 33 critical facility cells; all are owned by the AEC. About 1,200 individual reactor personnel were involved in the operation of these facilities. At the end of the year, there were two more AEC reactors under construction and one in planning.

A series of reviews of the reactor safety management practices is in progress by a task group consisting of AEC and industry specialists to provide additional assurance that a uniformly high level of safety is being maintained in the operation of AEC reactors and critical facilities.

Emergency Preplanning for AEC Facilities

Considerable improvements have been made in the emergency planning programs at AEC-owned facilities. To further improve the program, technical criteria covering radiological instruments that must be available for emergency use at nuclear facilities are being developed. These criteria will result in the application of uniform standards for installed and portable radiological emergency monitoring equipment.

The post graduate level medical seminars for physicians initiated in 1969 were continued during 1970. The attendees have expressed keen interest in this program with some of the initial groups indicating a desire for refresher training.

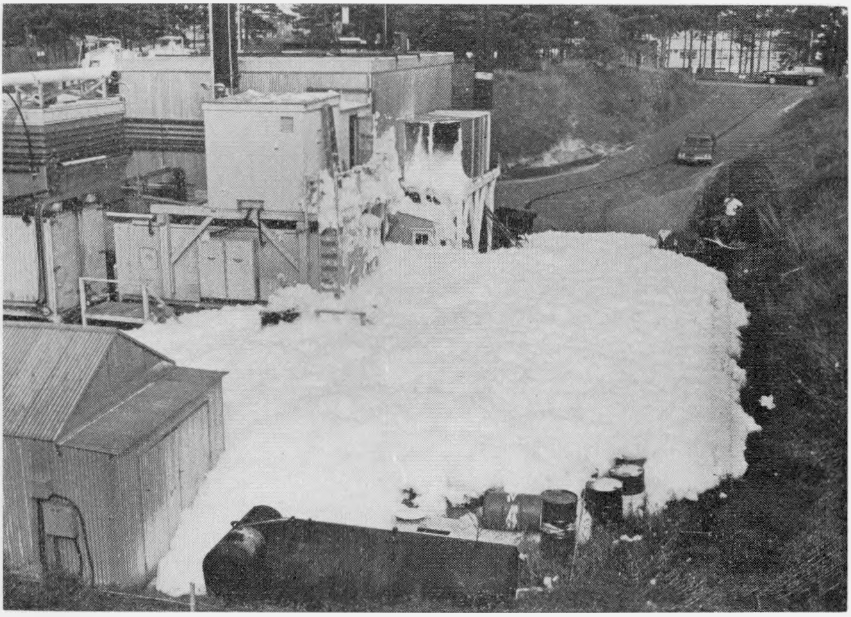
Another important part of the safety program is the area of independent reviews. During 1969, contracts had been signed with two outside consultant companies (Factory Insurance Association, and Factory Mutual Research Corp.) to assist the AEC in identifying fire protection weaknesses at key AEC weapon and production sites. These reviews were completed in 1970 and some of the recommendations have already been implemented. Eventually all of the recommendations will be considered for the AEC's preplanning safety program.

AEC Accidents and Property Damage

Ten fatalities occurred in 1970, none from radiation causes: Five resulted from airplane crashes, two from falls, two victims were crushed, and one drowned. The total damage to AEC property during 1970 was approximately $1,350,000. Roughly 60 percent of this amount was due to a single event (the K-reactor incident mentioned previously).

Radiation Exposures

An AEC contractor employee received estimated doses of 2,500 rem to the fingers of his left hand and 2,000 rem to small areas of his right



High-Expansion Firefighting Foam from a recent test of the automatic extinguishing system seeps out doors and windows at the Brookhaven National Laboratory's 7-foot Bubble Chamber. Prevention of fire is a continuous and serious concern at all AEC and AEC-contractor installations. Besides injury or death to employees, fires may result in destruction of valuable equipment and loss of many years of research work. A blanket of the foam will cool and contain a fire in short order and will not water-soak valuable equipment.

hand when he was accidentally exposed to beta radiation from fission products. He was attempting to recap a flow of highly radioactive liquid waste from a large transport cask. Another incident occurred as a result of a change in the energy of an accelerator beam without immediate recognition by the equipment operator, who thereby received an estimated exposure of 375 rems to his fingers. Nine lesser radiation exposures occurred, six external and three internal.

Low-Level Contamination

The AEC's Rocky Flats plant, which started operations in 1953, has released trace amounts of plutonium to the environment. However, these quantities are so minute that widely distributed offsite air samplers have never shown a level of radioactivity in excess of the natural background radiation that one expects in that part of the country. Even if it were assumed that all the background radiation measured offsite could be attributed to that from insoluble plutonium oxide particles rather than from normal background radiation, this background level would still only be a small percentage of officially recommended standards. Also, throughout the 17 years of operation, continuous water sampling has demonstrated that the level of plutonium contamination of water returned by the plant to the environment has always been substantially lower than the established radiation protection guidelines.

Chapter 3

LICENSING AND REGULATING THE ATOM

The AEC's regulatory program is carried out independent of the agency's operational and developmental activities; its function is to fulfill the AEC's statutory responsibilities of assuring that the possession, use, and disposal of radioactive materials, and the construction and operation of nuclear facilities are consistent with public health and safety and the common defense and security.

THE REGULATORY PROGRAM

The licensing and regulation of nuclear power reactors is a primary activity of the AEC with three organizational units below the Commissioner level participating in the process: The AEC regulatory staff; the Advisory Committee on Reactor Safeguards (ACRS);[1] and atomic safety and licensing boards (ASLB's). Each of these groups is independent of the others, and they are solely concerned with regulatory matters. While they have the benefit of safety research and information flowing from the AEC's developmental and operational activities, none of the three units has any developmental or operational responsibilities.

The Year—In Summary

The implementation of 1970 environmental quality legislation had increasing impact on the AEC regulatory program through the year, involving an enlargement of AEC responsibilities concerning nonradiological environmental effects of nuclear facilities and transfer to another agency of certain of the AEC's authority to set generally applicable environmental radiation standards.

[1] The ACRS and authority to create ASLB's were established by Congress, see Appendix 2 for functional statements and memberships.

Also, "practical value" amendments to the Atomic Energy Act at the end of the year made license applications for all commercial or industrial nuclear facilities subject to antitrust review by the Attorney General and the AEC.

Other factors having impact on licensing and regulation included: (*a*) Continuing increases in the numbers of nuclear powerplant applications for both construction permits and operating licenses; (*b*) an increase in the number of contested licensing proceedings; (*c*) expansion in scope of AEC compliance inspection and environmental sampling programs at licensed facilities, and (*d*) a continuing high level of effort to develop comprehensive safety standards for light water power reactors.

During the year, the AEC issued operating licenses for four nuclear powerplants, bringing installed central station nuclear power capacity to approximately 6,700 megawatts of electricity (Mwe.) from 19 plants. In addition, operating license applications for 27 nuclear power units were pending with the AEC at yearend, on which safety reviews were essentially completed for five units.

Nuclear fuel cycle activities also increased during 1970 as the AEC licensed the operation of a new uranium hexafluoride conversion plant and a fuel fabrication plant, and granted a construction permit for the Nation's third investor-owned irradiated fuel reprocessing plant. A construction permit application also was received for a fourth chemical reprocessing plant.

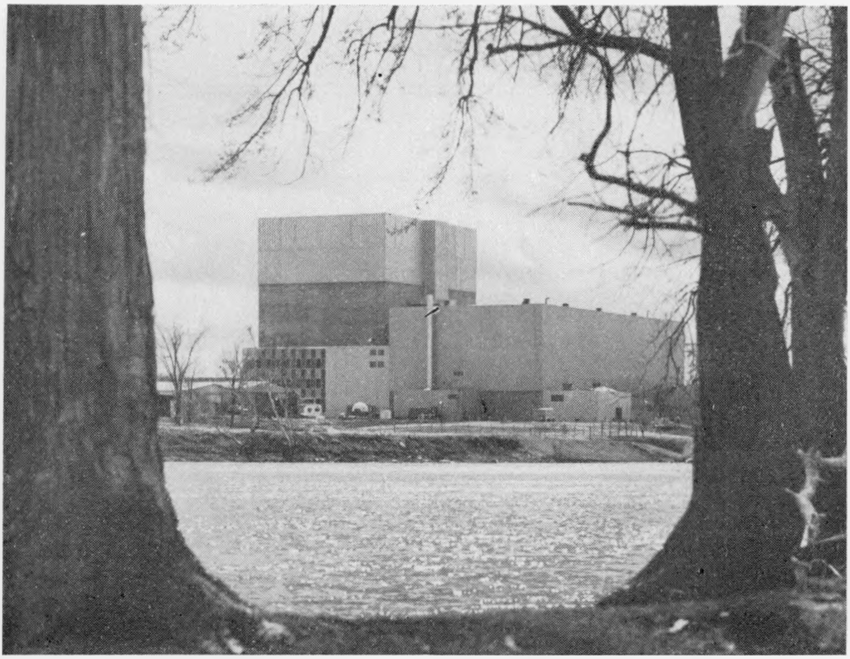
The use of atomic energy materials, licensed by both the AEC and the 22 States which have assumed certain of the AEC's regulatory authority, increased moderately. The AEC initiated a program of contractual arrangements with individual States to conduct environmental monitoring programs at power reactor installations. Jurisdictional problems continued with certain of the States regarding limits on releases of radioactivity from nuclear facilities. (For regulatory actions in the safeguarding of special nuclear materials from the standpoint of the common defense and security, see Chapter 4.)

Jurisdiction Over Regulation of Reactors

The Northern States Power Co. had filed, during 1969, a suit in the U.S. District Court for the District of Minnesota for a declaratory judgment and injunction against the State of Minnesota, seeking a declaratory judgment as to the Minnesota Pollution Control Agency's permit limits for the discharge of radioactive effluents. The State agency had issued a waste disposal permit in June 1969 for the company's Monticello Nuclear Generating Plant which set limits for the discharge of radioactive effluents at a small fraction of the discharge levels permitted by AEC regulations (10 CFR Part 20).[2]

The utility's suit was filed on the ground that the Atomic Energy Act of 1954, as amended, preempted to the Federal Government exclusive authority to regulate radioactive discharges from nuclear powerplants. The issue, stated more concretely, is whether Minnesota

[2] See p. 140, "Annual Report to Congress for 1969." AEC licensing action in the Monticello case is also described in this chapter under "Reactor Licensing Actions," and "Adjudicatory Activities" in Chapter 14.



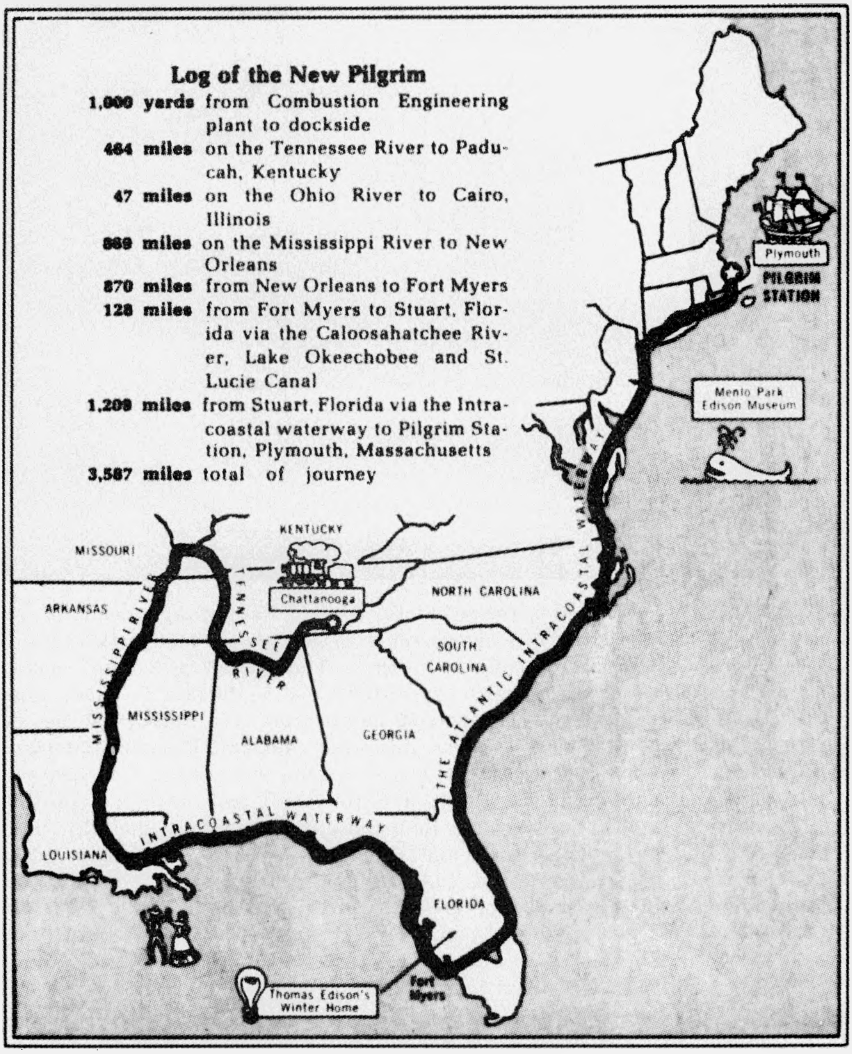
The Monticello Nuclear Generating Plant, located on the west bank of the Mississippi River in Minnesota, is destined to become a "landmark" case in the reactor licensing and regulation process. The operating license application was the first to be contested since 1963; on September 8, fuel-loading and low-power startup (up to 5 thermal megawatts) was authorized for the 545-megawatts of electricity (Mwe.) boiling water, General Electric-built plant. A number of important issues were raised during the operational licensing phase, among them being the right of a State to set more stringent controls on discharge of radioactive effluents than those established by the AEC. Public hearings by an atomic safety and licensing board (ASLB) also led to questions concerning whether the AEC regulatory staff's periodic, onsite inspection reports of construction progress could be made public without deletion of certain information considered privileged. At yearend, the AEC's rules were revised to settle the latter questions, and a U.S. District Court ruled that Federal regulations preempt those of a State governing the discharge of radioactive effluent.

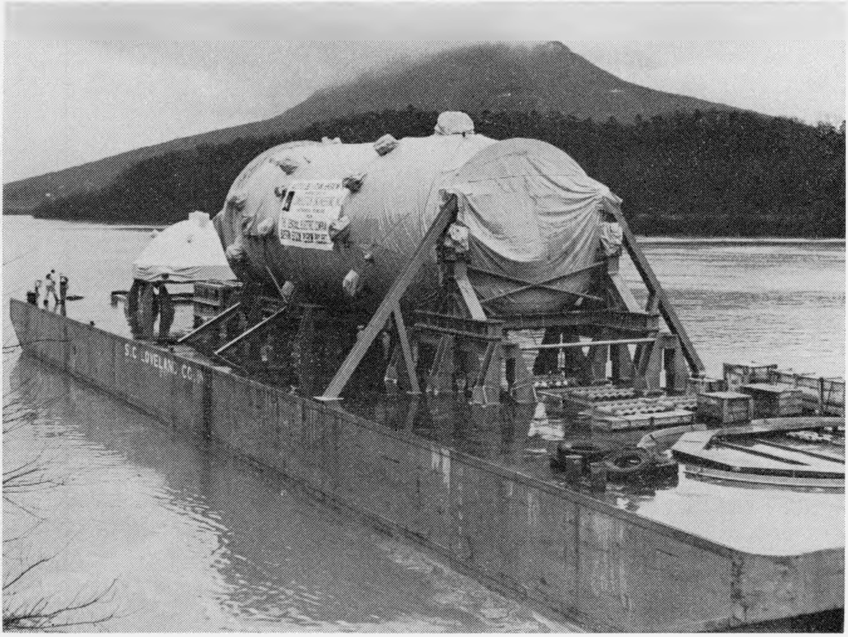
412-406--71——6

has authority to impose restrictions, from the standpoint of radiological health and safety, on Northern States' Monticello facility.

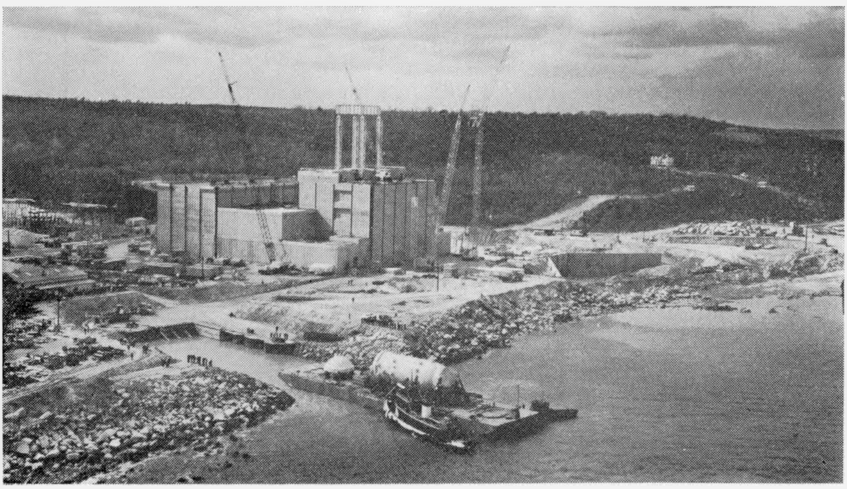
During 1969 and 1970, the following States intervened to support the Minnesota position: Michigan, Illinois, Vermont, Wisconsin, Missouri, Pennsylvania, Maryland, and the Southern Governors' Conference (representing Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia, Puerto Rico, and the Virgin Islands).

On December 22, 1970, the court rendered its decision—on the basis of pleadings, stipulations, and briefs—upholding the Northern States Power Co.'s position.





As "The Crow Flies" it is slightly under 1,000 miles from Chattanooga, Tenn., to Plymouth Rock in Massachusetts. However, the 525-ton, 65-foot-tall reactor vessel for the Boston Edison Co.'s Pilgrim Nuclear Station took a month-long, 3,587-mile voyage (see map on opposite page) to go from the fabrication shops to the plantsite. It was a cloudy January day when the vessel—dubbed "New Pilgrim"—left Combustion Engineering's dock (*above*) on the Tennessee River; however, the sun broke through the clouds on February 27, 1970, as the "New Pilgrim" (*below*) was nudged into a landing—about a mile south of the spot where the Pilgrims had landed 350 years before. The 654-Mwe. General Electric boiling water reactor is scheduled to begin operation in 1971. The application for an operating license was received by the AEC in January 1970.



Licensees' Radiation Safety Record

AEC licensees, during 1970, continued to compile a generally good overall radiation safety record, based on results of inspections by AEC compliance personnel, safety experience surveys by the U.S. Bureau of Labor Statistics, and records of film badge exposures for the year.

Licensed Reactors. Since the beginning of the "civilian program" in 1954, the AEC has licensed the operation of 122 power, test, and research reactors. These facilities have been operated through 1970 without a radiation fatality or a serious radiation exposure to any member of the general public.[3] No instance is known where the operation of nuclear powerplants has resulted in over-exposures to operating personnel or the public, nor in the release of radioactivity exceeding annual limitations set by AEC regulations.

There was one instance of overexposure in a licensed research reactor operation during the year. A graduate student received an overexposure to one hand as the result of withdrawing an irradiated sample from a university reactor while checking the experimental port for obstructions.

Materials Licensees. During the 24 years since the AEC began licensing the possession and use of atomic energy materials, one radiation fatality has occurred among thousands of licensed activities.[4] Twelve other persons have been recorded as receiving radiation exposures serious enough to show clinical symptoms.

ENVIRONMENTAL QUALITY ACTIONS

Until 1970, the AEC's regulatory authority under the Atomic Energy Act of 1954, as amended, had been limited essentially to radiological health and safety and common defense and security considerations.[5] However, the enactment of two Federal laws during 1970 enlarged the AEC's responsibilities concerning environmental matters with increas-

[3] Only one fatal accident involving reactors has occurred in the United States. At a nonlicensed Army experimental reactor designed for operation in remote areas, three technicians died during a nuclear excursion at the National Reactor Testing Station in Idaho in 1961. The accident at this early experimental reactor was believed to have been caused in part by failure of the personnel involved to follow prescribed maintenance procedures. No excessive offsite release of radioactivity occurred, 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.")

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

[5] U.S. Court of Appeals for the First Circuit (Boston) upheld the Commission's interpretation on Jan. 13, 1969, and the U.S. Supreme Court subsequently denied a petition for review. (See pp. 139–140, "Annual Report to Congress for 1969.")

ing impact on licensing activities throughout the year. These laws were the National Environmental Policy Act of 1969 (NEPA) and the Water Quality Improvement Act of 1970. (See Chapter 2, "Environmental and Safety Aspects.")

NATIONAL ENVIRONMENTAL POLICY ACT

In December, the AEC adopted a revised statement of general policy on implementation of the NEPA in its regulatory program which provided for much fuller consideration than in the past of the whole range of nonnuclear environmental issues in the licensing of nuclear powerplants and fuel reprocessing facilities.[6]

AEC Statement of Policy

The revised statement of policy—which was preceded by an initial policy statement issued on April 2 and a proposed revision published in the *Federal Register* on June 3, took into account guidelines announced by the Council on Environmental Quality and requirements of the new Water Quality Improvement Act of 1970 (see Appendix 4).

Consideration of the principal environmental effects of nuclear power facilities (radiological and thermal) is accomplished through the AEC licensing process and through application of water quality legislation which has established a system of Federally approved State standards (see "Water Quality Certification" section in this chapter). The statement also urges the appropriate agencies to proceed promptly to establish standards and requirements for the other aspects of environmental quality.

The AEC statement expressly recognizes the necessity for expediting the decision-making process and avoiding undue delays in providing adequate electric power on reasonable schedules, while at the same time protecting environmental quality.

Environmental Reports from Applicants

Under the policy, all applicants for construction permits and operating licenses for nuclear power reactors and fuel reprocessing plants are required to submit to the AEC an environmental report on their facilities; those submitted on or after December 4, 1970, must include discussion of water quality aspects.

---

[6] Amendments to 10 CFR Part 50, Appendix D, "Licensing of Production and Utilization Facilities," published in the *Federal Register* of December 4, 1970.

In addition, reports are required from holders of construction permits which have not yet applied for an operating license.

Detailed Environmental Statements

Detailed environmental statements, as required by the NEPA, will be prepared by the AEC in all cases in which an environmental report has been filed.

In cases where an environmental report is submitted on or after December 4, 1970, the report and a draft AEC detailed statement are to be transmitted to appropriate Federal agencies [7] and made available to appropriate State and local agencies authorized to develop and enforce environmental standards, for review and comment. After the comment period, the AEC will prepare the final detailed statement and forward it to the Council on Environmental Quality and the concerned agencies.

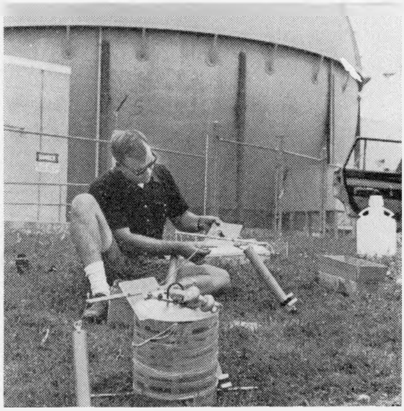
In general, the environmental statements on power facilities discuss: (*a*) Site and reactor characteristics; (*b*) power needs in the area; (*c*) the environmental impact, including radiological and nonradiological effects; (*d*) any provision for enhancement of environmental amenities, such as recreational and ecological facilities; (*e*) alternatives to the proposed action; (*f*) any adverse environmental effects that cannot be avoided; (*g*) relationship between local short-term uses and maintenance and enhancement of long-term productivity; and (*h*) any irreversible and irretrievable commitments of resources.

Consideration of Environmental Issues

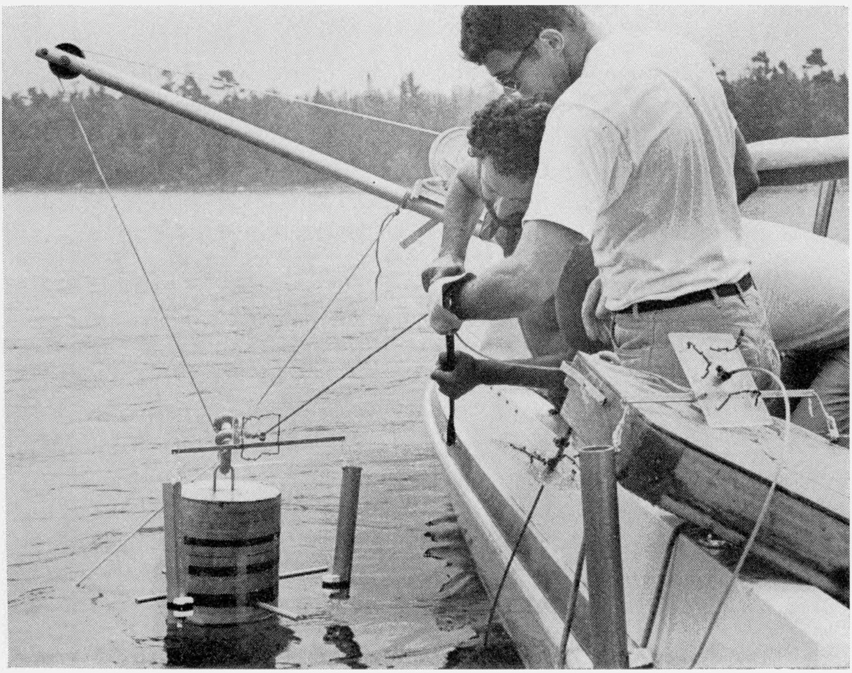
The general policy statement authorizes AEC's atomic safety and licensing boards (ASLB's) to consider, under NEPA, environmental matters to the extent that a party raises an issue whether the permit or license would be likely to result in a significant, adverse effect on the environment (other than water quality matters covered by the Water Quality Improvement Act of 1970 and radiological effects covered by other AEC regulations).

If such an adverse effect were indicated, the AEC would consider the

[7] Environmental Protection Agency; Federal Power Commission; and Departments of Agriculture, Commerce, Defense, Housing and Urban Development, Interior, Transportation and Health, Education, and Welfare.



With 10 Nuclear Stations Scheduled for future operation on the shores of Lake Michigan alone, the 8-year-old Big Rock Point plant (*upper left*) of Consumers Power Co. of Michigan is proving a good study area for determining the possible influence on the environment of nuclear powerplants sited along the Great Lakes. With the cooperation of the utility firm, Argonne National Laboratory is conducting an on-the-site study of the thermal discharge plume and collecting water, sediment, and biological samples near the boiling water reactor steam generating plant's outlet. In photo at *upper right* an Argonne scientist prepares a dosimetry buoy for placement in Lake Michigan near the Charlevoix site. The buoys are used to determine if detectable amounts of radioactivity are in the lake from nuclear powerplants. Photo *below* shows the dosimetry buoy being placed in the lake.



need for requirements to preserve environmental values consistent with other national policy considerations, including the need to meet electric power requirements on a timely basis.

Proof that an applicant is equipped to observe, and agrees to observe, already existing environmental quality standards and requirements would be considered a satisfactory showing that there will not be a significant adverse effect on the environment; and an appropriate certification would settle the matter.

If no such issue is raised, the AEC's responsibilities under NEPA will be carried out *in toto* outside the hearing process.

License Conditions

Under the policy statement, all construction permits and operating licenses will be conditioned on observance of environmental protection requirements which are validly imposed under Federal and State law, and which are determined by the AEC to be applicable. This condition will be included in licenses previously issued which do not now have the condition. It does not apply to radiological effects, which are dealt with in other provisions of the permit or license, or to water quality matters covered by the Water Quality Improvement Act of 1970, for which a separate condition will be provided (see below).

Materials Facilities Covered

The statement provides that similar procedures will be followed in other AEC licensing proceedings on proposals significantly affecting the environment, including licenses for: (*a*) Nuclear fuel fabrication plants, scrap recovery facilities, and uranium hexafluoride conversion plants; (*b*) uranium milling and production of uranimum hexafluoride; and (*c*) commercial radioactive waste disposal by land burial.

Water Quality Certification

The Water Quality Improvement Act of 1970 (WQIA) amended the Federal Water Pollution Control Act to require certification that there is reasonable assurance that Federally licensed activities which may result in discharges into navigable waters of the United States will not violate applicable water quality standards (including thermal standards). Applicants for an AEC permit or license for such activities (*e.g.*, nuclear powerplants) generally must provide this certification before a permit or license can be issued. The certification is to come from the State or interstate water pollution control agency, or the Administrator of the Environmental Protection Agency (EPA), as appropriate. Certain interim exemptions from the requirement were provided for applications pending and for facilities already under construction on the date of enactment.[8]

The AEC interpreted the water quality certification law as superseding, to the extent that it applies to water quality matters, the broader National Environmental Policy Act.

Transfer of Functions to EPA

On December 2, 1970, the new Environmental Protection Agency became operative, consolidating in one agency, certain pollution control programs formerly existing in four separate agencies and an interagency council.[9]

In the field of radiation, the EPA acquired all functions formerly vested in the interagency Federal Radiation Council (FRC), which was abolished. Since 1959, the FRC had provided official guidance in the United States to Federal agencies in the form of radiation protection guides for occupational workers, individual members of the public, and the population as a whole. The EPA also assumed that part of the AEC's authority, as had been administered by its Division of Radiation Protection Standards, to develop and set generally applicable environmental radiation standards for the protection of the general environment.

The AEC retained responsibility to implement and enforce, through its licensing and regulatory authority, the environmental radiation standards to be developed by EPA. In implementing these standards, the AEC will establish regulatory requirements applying to persons who receive, possess, use, or transfer byproduct, source, or special nuclear material, or who construct or operate nuclear facilities. These

---

[8] Section 21(b)(7) of the WQIA provides that where construction had commenced prior to date of enactment (April 3, 1970), the period of time within which certification must be obtained is extended until April 3, 1973. Regarding applications for a permit or license which were pending on the date of enactment, Section 21(b)(8) provides that those permits or licenses issued within one year after April 3, 1970, may remain in effect without certification for one year following issuance, after which certification will be required.

[9] The President's Reorganization Plan No. 3 of 1970, sent to Congress on July 9, dealt with five basic areas of pollution—water, air, solid waste, pesticides and radiation. EPA combines functions formerly carried out by the Federal Water Quality Administration (Department of the Interior); the National Air Pollution Control Administration, parts of the Environmental Control Administration, and the pesticides research and regulatory programs of the Food and Drug Administration (Department of Health, Education, and Welfare); the pesticides registration and related authority of the Department of Agriculture; some pesticides research of the Bureau of Commercial Fisheries; ecological systems research authority of the Council on Environmental Quality; all functions of the Federal Radiation Council; and the environmental radiation protection standard-setting function of the AEC.

requirements include such items as design criteria, operating procedures, limits on radioactivity in the effluents released outside the boundaries of locations under the control of the user, and monitoring to develop data to demonstrate compliance with AEC requirements.

The AEC and other Federal agencies, in conducting direct activities not subject to AEC licensing, will use the EPA environmental standards as guidelines.

REACTOR LICENSING ACTIONS

The licensing process for nuclear power reactors, as well as other major nuclear utilization and production facilities, requires a series of technical reviews and public hearings. A construction permit application is first reviewed by the AEC's regulatory staff to determine that there is reasonable assurance that the proposed facility can be constructed and operated safely at the proposed site. The construction application is also given an independent technical evaluation by the Advisory Committee on Reactor Safeguards (ACRS) as required by section 29 of the Atomic Energy Act of 1954, as amended. The reviews are followed by public hearings conducted by an atomic safety and licensing board (ASLB) appointed from a qualified panel for each proceeding. The initial decision of the ASLB is subject to review by an appeals board and/or by the Commission. The procedure is repeated later when the facility is ready for an operating license, except that public hearings are not held unless requested or the Commission, on its own initiative, schedules a hearing. (The summaries of 1970 activities of the ACRS and the ASLB's, as well as other adjudicatory activities, concerning the licensing of reactors and a fuel reprocessing plant are included in Chapter 14—License Reviews and Adjudicatory Proceedings.)

Increases in the number of applications for both construction permits and operating licenses for nuclear powerplants continued during 1970. During the year, the AEC licensed the initial operation of four large nuclear units, authorized resumption of operation of another plant, and issued construction permits for 10 new plants.

Status of Civilian Nuclear Power

At the end of 1970, central station nuclear powerplants in operation, under construction, or for which AEC construction applications and operating licenses were pending (or not yet applied for) totaled 108 units, representing approximately 86,103 Mwe. as follows:

- Nineteen authorized to operate, with a total capacity of 6,708 Mwe.;[10]
- Fifty-three under construction (including three awaiting operating licenses) with 44,040 Mwe. total initial capacity; and
- Thirty construction applications were under review at yearend representing 29,103 Mwe. of capacity; there were another five units (6,424 Mwe.) which had been contracted for but for which construction applications had not been filed.

REACTOR OPERATING LICENSES

Public hearings requested by environmental groups and other intervenors extended operating license proceedings concerning several completed nuclear powerplants in 1970. During the year, the AEC licensed the initial operation of four large nuclear electric plants, authorized resumption of operation of one unit, and retired another early prototype plant, bringing total installed nuclear power to approximately 6,708 Mwe., net.

In addition, the AEC completed technical safety reviews on five other nuclear units scheduled for early operation pending the issuance of licenses. Three of these, which were the subject of public hearings before atomic safety and licensing boards at yearend, included Consumers Power Co.'s Palisades Plant (Mich.), Consolidated Edison Co.'s Indian Point Unit 2 (N.Y.), and Commonwealth Edison Co.'s Dresden Unit 3 (Ill.).

At yearend, 18 operating license applications for 27 units, totaling 22,805 Mwe. were still under review (see Table 1).

New Operating Licenses

Operating licenses were issued during 1970 for four new nuclear powerplants.

---

[10] 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 Generating 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.); Humboldt Bay Unit 3 and San Onofre Nuclear Generating Station Unit 1 (Calif.); LaCrosse Boiling Water Reactor and Point Beach Unit 1 (Wis.); Connecticut Yankee Atomic Power Plant and Millstone Point Unit 1 (Conn.); Oyster Creek Unit 1 (N.J.); Monticello Nuclear Generating Plant (Minn.); and H. B. Robinson Unit 2 (S.C.). Does not include reactors which have been shut down permanently: Hallam (Nebr.) Nuclear Power Facility, Carolinas-Virginia Tube Reactor (S.C.), Pathfinder Atomic Power Plant (S. Dak.); Piqua (Ohio) Nuclear Power Facility, Boiling Nuclear Superheat Reactor (BONUS) (Puerto Rico); and Elk River Nuclear Plant (Minn.).

H. B. Robinson Unit 2

On July 31, the Carolina Power & Light Co. was licensed to load, test, and operate its H. B. Robinson S.E. Plant, Unit 2, at power levels up to 5 thermal megawatts (Mwt.). The reactor achieved a chain reaction on September 20. After determining that all construction questions had been resolved, the AEC authorized operation at 2,200

TABLE 1.—NUCLEAR POWERPLANT OPERATING LICENSE APPLICATIONS UNDER REVIEW

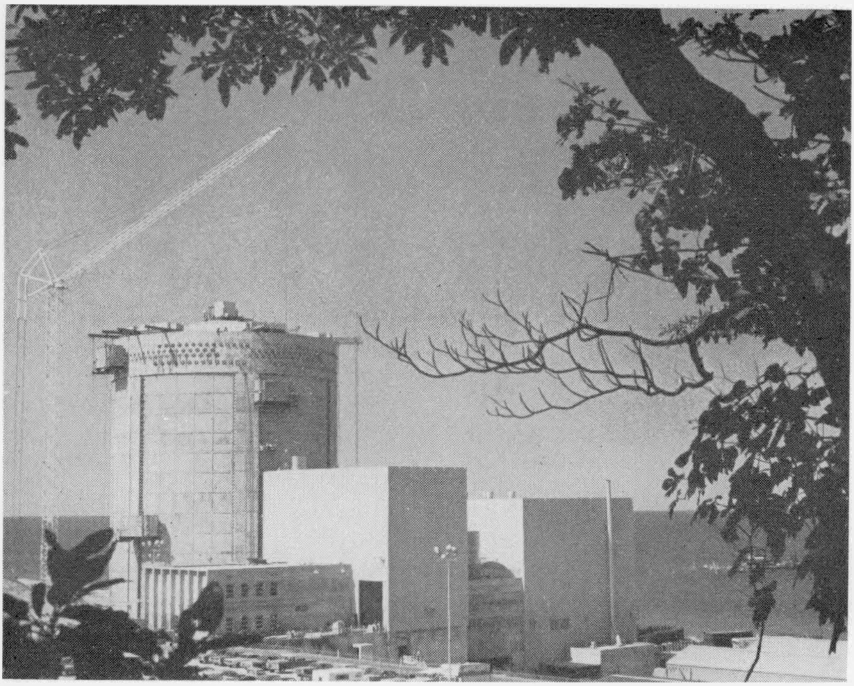
Applicant	Plant (location)	Date application received	Unit size[1] (net Mwe.)	Projected operation (year)
Commonwealth Edison Co	Dresden-3 (Morris, Ill.)	November 1967	809	1971
Commonwealth Edison Co.,	Quad-Cities-1	September 1968	809	1971
Iowa-Illinois Gas & Electric Co.	Quad-Cities-2 (Cordova, Ill.).	September 1968	809	1972
Consolidated Edison Co. of New York.	Indian Point-2 (Buchanan, N.Y.).	October 1968	873	1971
Consumers Power Co	Palisades (S. Haven, Mich)	November 1968	700	1971
Wisconsin Michigan Power Co., Wisconsin 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	1971
	Oconee-2	June 1969	886	1972
	Oconee-3 (Seneca, S.C.).	June 1969	886	1973
Public Service Co. of Colo	Ft. St. Vrain (Platteville, Colo.).	November 1969	330	1972
Omaha Public Power District	Ft. Calhoun-1 (Ft. Calhoun, Nebr.).	November 1969	457	1972
Boston Edison Co	Pilgrim (Plymouth, Mass.)	January 1970	654	1971
Vermont Yankee Nuclear Power Corp.	Vermont Yankee (Vernon, Vt.).	January 1970	514	1971
Virginia Electric & Power Co	Surry-1	January 1970	780	1971
	Surry-2 (Gravel Neck, Va.).	January 1970	780	1972
Metropolitan Edison Co	Three Mile Island-1 (Goldsboro, Pa.).	March 1970	810	1972
Philadelphia Electric Co	Peach Bottom-2	August 1970	1,065	1972
	Peach Bottom-3 (Peach Bottom, Pa.).	August 1970	1,065	1973
Maine Yankee Atomic Power Co.	Maine Yankee (Wiscasset, Maine).	August 1970	790	1972
Tennessee Valley Authority	Browns Ferry-1	September 1970	1,065	1972
	Browns Ferry-2	September 1970	1,065	1973
	Browns Ferry-3 (Decatur, Ala.).	September 1970	1,065	1973
Commonwealth Edison Co	Zion-1	November 1970	1,050	1972
	Zion-2 (Zion, Ill.).	November 1970	1,050	1973
Consolidated Edison Co. of N.Y.	Indian Point-3 (Buchanan, N.Y.).	December 1970	965	1973

[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-2, Oconee-2 and 3, and Pilgrim Station.

Mwt. on September 23. The pressurized water reactor facility, located near a fossil-fueled unit on the same site on Lake Robinson, about 5 miles from Hartsville, S.C., is rated at about 700 Mwe. (net) at full power. Westinghouse Electric Corp. provided the nuclear steam supply system, and Ebasco Services, Inc., was architect-engineer-constructor.

Monticello Nuclear Station

Northern States Power Co.'s application to operate its Monticello Nuclear Generating Station on the Mississippi River near Monticello, Minn., was the first operating license application to be contested since the Enrico Fermi Atomic Power Plant proceeding in 1963 and 1964. The AEC scheduled a hearing in the matter before an atomic safety



The Palisades Nuclear Power Station, near South Haven, Mich., for which an operating license was still pending at yearend, will be the Consumers Power Co. of Michigan's second nuclear unit when it goes into operation. Consumers Big Rock Point plant (a 70-Mwe. boiling water General Electric reactor) has been operating since 1962. The new Palisades unit is a 700-Mwe. pressurized water reactor built by Combustion Engineering. Hearings on the contested application were held during 1970 before an ASLB and will resume in 1971.

and licensing board (ASLB), in St. Paul, Minn.[11] The Minnesota Environmental Control Citizens Association (MECCA) and two other petitioners intervened in the protracted proceeding which saw intermittent hearing sessions and conferences from April 7 to November 20, when the hearing was concluded. Grounds for intervention were based on radiological health and safety matters. Legal questions novel to AEC licensing proceedings involved the subpoenaing of AEC regulatory documents, requested by MECCA. (For adjudicatory actions in the case, see Chapter 14.)

After an initial ASLB decision of August 24 authorizing issuance of a provisional operating license for fuel loading and low-power startup testing, the AEC issued a limited license on September 8. At yearend, the ASLB's initial decision on the application for a full power license was pending.

The Monticello plant is a boiling water reactor facility rated at 545 Mwe. at full power of 1,670 thermal megawatts. General Electric Co. was the designer, engineer, and constructor; Chicago Bridge & Iron Co. assembled the reactor pressure vessel at the site.

Point Beach Unit 1

Wisconsin Michigan Power Co. and Wisconsin Electric Power Co. were issued a full-term operating license on October 5 for operation of the Point Beach Nuclear Plant, Unit No. 1 at 1,518 Mwt., producing 497 Mwe. The facility, a pressurized water reactor, is located on the western shore of Lake Michigan in the town of Two Creeks, Manitowoc County, Wis. Westinghouse was prime contractor, and Bechtel Corp. the engineer-constructor.

Unit 1 became operational on November 2. Unit 2, nearing completion at the same site, is planned for operation in mid-1971.

Millstone Point Unit 1

On October 7, a provisional operating license was issued to the Millstone Point Co. authorizing fuel loading of a boiling water reactor designated as the Millstone Nuclear Power Station Unit 1.[12] On October 26, after inspection of the installation and certain testing, the

---

[11] In compliance with section 189 of the Atomic Energy Act, the AEC publishes a notice of intent to issue each power reactor operating license with provision for the filing of petitions to intervene within 30 days of publication. The Commission may also schedule a hearing on its own initiative.

[12] The Millstone Station is a cooperative project by the Connecticut Light & Power Co., Hartford Electric Light Co., Western Massachusetts Electric Co., and Millstone Point Co., all wholly-owned subsidiaries of Northeast Utilities.

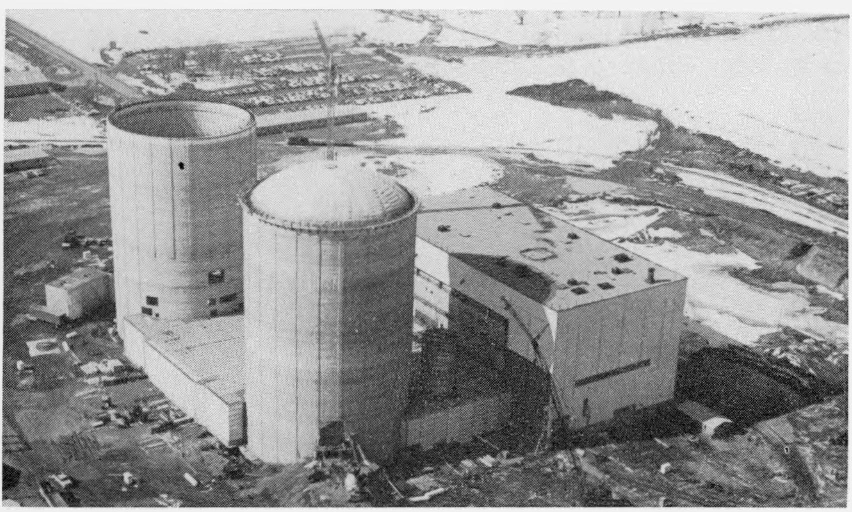
AEC authorized operation of the plant at its full design power of 2,011 Mwt., producing about 652 Mwe. The reactor became operational on October 27.

The Millstone site, where a pressurized water unit was also placed under construction in December, is in Waterford, Conn. on the north shore of Long Island Sound, 3.2 miles from New London and 40 miles southeast of Hartford.

Other Operating License Actions

Fermi 1. During the year, the Power Reactor Development Co. (PRDC) resumed operation of its Enrico Fermi Atomic Power Plant Unit 1 after a shutdown of nearly 4 years. The sodium-cooled, fast breeder demonstration reactor underwent modifications after an operating malfunction in October 1966 resulted in some localized fuel melting. The AEC authorized fuel loading in February 1970, and subsequently reexamined plant operators to determine that they had adequate knowledge of revised operating procedures. The reactor again became operational on July 18, 1970, and reached its maximum authorized power level of 200 Mwt. in October.

Elk River. In June, the operating license for the Elk River Nuclear Plant in Minnesota was replaced with a "possession only" license.



Two Giant Silo-Like Containment Shells almost dwarf the generating hall at Northern States Power Co.'s Prairie Island site near Red Wing, Minn. An operating license application for the Westinghouse-built pressurized water reactor was received by the AEC during August 1970. The two-unit plant is designed to generate a total of 1,060 Mwe. Unit 1 is scheduled for operation in 1972, Unit 2 in 1974.

The 22-Mwe. boiling water reactor plant sustained a nuclear chain reaction in 1962, reached design power in 1964, and operated through 1967. Operated for AEC by the Rural Cooperative Power Association, the plant has been shut down since February 1968 because of leakage in the primary reactor system.

Oyster Creek 1. On December 2, Jersey Central Power and Light Co.'s license for its Oyster Creek Nuclear Power Plant, Unit 1, was amended to authorize operation up to 1,690 thermal megawatts producing about 560 Mwe.

Non-Electric Generating Reactor. The AEC also authorized full-power operation of the Southwest Experimental Fast Oxide Reactor (SEFOR) near Fayetteville, Ark., and issued a full-term license to the National Bureau of Standards (NBS) for its test reactor near Gaithersburg, Md. The 20-Mwt. SEFOR reactor plant does not produce power but is being 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). The NBS reactor, a high-flux, heavy water-moderated and -cooled facility, was issued a 15-year license to operate at steady state power levels not to exceed 10 Mwt.

CONSTRUCTION PERMITS

At the end of 1970, 53 nuclear electric powerplants, ranging in capacity from 330 Mwe. to 1,140 Mwe. each, were in various stages of

TABLE 2.—CONSTRUCTION PERMITS ISSUED FOR NUCLEAR POWERPLANTS—1970

Applicant	Plant (location)	1970 date issued	Unit size (net Mwe.)	Projected operation (year)
Carolina Power & Light Co	Brunswick-1	February 7	821	1974
	Brunswick-2 (Southport, N.C.)	February 7	821	1976
Power Authority of the State of N.Y.	FitzPatrick (Scriba, N.Y.)	May 20	821	1973
Tennessee Valley Authority	Sequoyah-1	May 27	1,124	1974
	Sequoyah-2 (Daisy, Tenn.)	May 27	1,124	1974
Iowa Electric Light & Power Co.	Arnold-1 (Cedar Rapids, Iowa).	June 22	545	1973
Duquesne Light Co	Beaver Valley (Shippingport, Pa.).	June 26	847	1973
Florida Power & Light Co	Hutchinson Island (Ft. Pierce, Fla.).	July 1	813	1973
Pacific Gas and Electric Co	Diablo Canyon-2 (Avila, Calif.).	December 9	1,060	1974
Connecticut Light & Power Co. *et al.*	Millstone Point-2 (Waterford, Conn.).	December 11	828	1974

construction in 24 States. Nearly all of these units are scheduled by the utilities for operation by 1975.

New Construction Permits

Construction permits were issued in 1970 to eight utilities for 10 new nuclear powerplants (see Table 2) to be located in California, Connecticut, Florida, Iowa, New York, North Carolina, Pennsylvania, and Tennessee.

The largest authorized was the Tennessee Valley Authority's twin-unit Sequoyah station on Chickamauga Lake, Tennessee River, 12 miles from Chattanooga, which will produce 1,124-Mwe. from each of two Westinghouse pressurized water reactors.

In addition to the 10 construction permits issued, the AEC had completed technical safety reviews of applications for seven other nuclear power units which were in the hearing stage before atomic safety and licensing boards at yearend. These included: Toledo Edison Co.'s Davis-Besse plan in Ohio; Portland General Electric Co.'s Trojan plant in Oregon; Long Island Lighting Co.'s Shoreham Station in New York; Consumers Power Co.'s Midland Units 1 and 2 in Michigan; and Virginia Electric & Power Co.'s North Anna Units 1 and 2.

New applications for construction permits continued a 3-year increase as 13 utilities filed for 19 units, most of which are projected for twin-unit stations. At yearend the AEC had under active review the applications of 20 utilities for permits to construct 30 nuclear power units (see Table 3). All of the proposed plants are scheduled for commercial operation by 1977.

OTHER REACTOR LICENSING

In the interests of public safety, personnel who operate reactors must be licensed by the AEC. The export of reactors also requires AEC authorization.

Reactor Operator Licenses

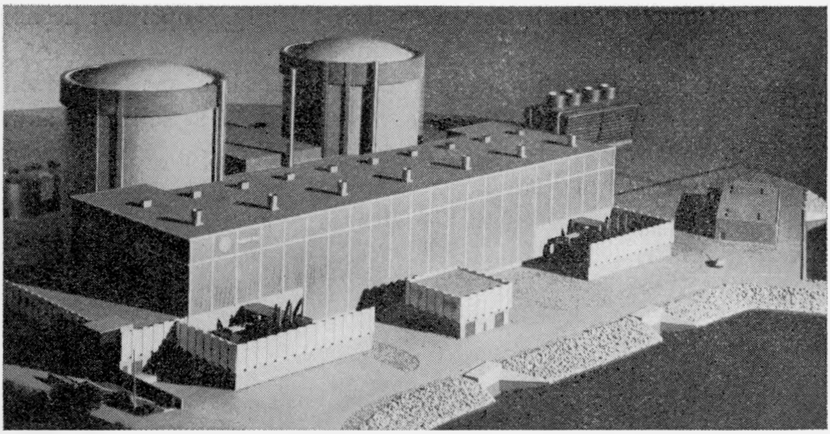
Operators who handle or supervise manipulation of reactor controls are examined by the AEC and licensed on an individual basis. In 1970, the AEC issued, amended, or renewed 326 operator licenses and 423 senior operator licenses. Of these 318 were new licenses. In addition,

412-406—71——7

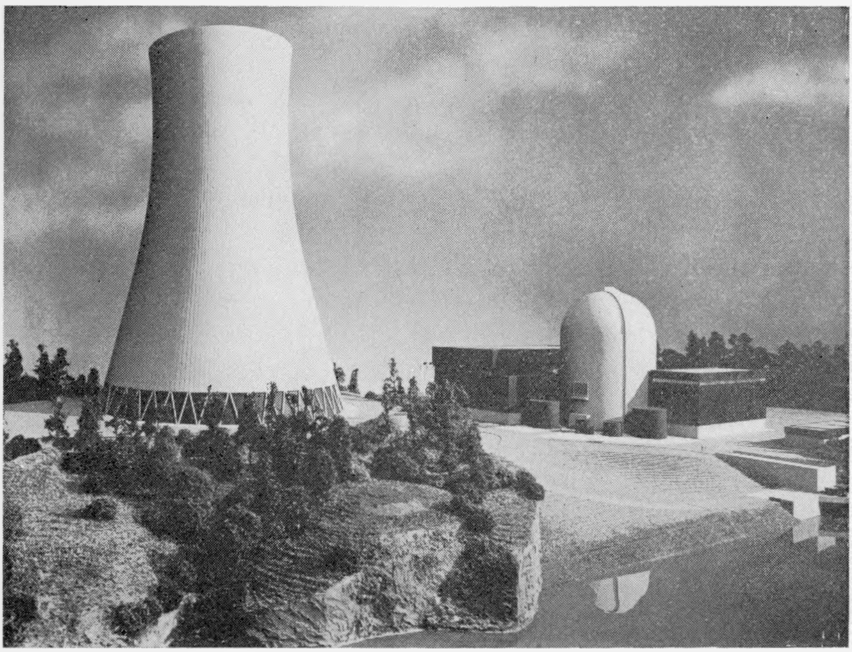
TABLE 3.—NUCLEAR POWERPLANT CONSTRUCTION APPLICATIONS UNDER REVIEW
(As of Dec. 31, 1970)

Applicant	Plant (location)	Date received	Unit size (net Mwe.)	Projected operation (year)
Los Angeles Dept. of Water & Power.	Malibu [1] (Corral Canyon, Calif.).	November 1963	462	
New York State Electric & Gas Corp.	Bell Station [2] (Lansing, N.Y.).	March 1968	838	
Long Island Lighting Co	Shoreham (Shoreham, N.Y.).	May 1968	819	1975
Consumers Power Co. of Mich	Midland-1	October 1968	492	1974
	Midland-2	October 1968	818	1975
	(Midland, Mich.)			
Virginia Electric & Power Co	North Anna-1	March 1969	845	1974
	North Anna-2	March 1969	845	1975
	(Mineral, Va.)			
Public Service Co. of New Hampshire.	Seabrook-1 [1] (Seabrook, N.H.).	April 1969	860	
Detroit Edison Co	Fermi-2 (Lagoona Beach, Mich.).	April 1969	1,123	1974
Consolidated Edison Co. of N.Y., Inc.	Nuclear Unit-4	June 1969	1,115	1978
	Nuclear Unit-5	June 1969	1,115	1979
	(Verplanck, N.Y.)			
Portland General Electric Co	Trojan (Rainier, Ore.)	June 1969	1,130	1974
Toledo Edison Co., *et al*	Davis-Besse (Oak Harbor, Ohio)	August 1969	872	1974
Alabama Power Co	Farley-1	October 1969	829	1975
	Farley-2	June 1970	829	1977
	(Dothan, Ala.)			
Philadelphia Electric Co	Limerick-1	February 1970	1,065	1975
	Limerick-2	February 1970	1,065	1977
	(Limerick, Pa.)			
Public Service Electric & Gas Co. of N.J.	Newbold Island-1	February 1970	1,088	1975
	Newbold Island-2	February 1970	1,088	1977
	(Bordentown, N.J.)			
Cincinnati Gas & Electric Co	Zimmer-1 (Moscow, Ohio)	April 1970	810	1975
Southern California Edison Co., San Diego Gas & Electric Co.	San Onofre-2	June 1970	1,140	1975
	San Onofre-3	June 1970	1,140	1976
	(San Clemente, Calif.)			
Jersey Central Power & Light Co.	Forked River-1 (Lacey Township).	June 1970	1,140	1976
Georgia Power Co	Hatch-2 (Baxley, Ga.)	July 1970	786	1976
Northern Indiana Public Service Co.	Bailly (Dunes Acres, Ind.)	August 1970	660	1976
Arkansas Power & Light Co	Arkansas-2 (London, Ark.)	September 1970	920	1975
Duke Power Co	McGuire-1	September 1970	1,150	1975
	McGuire-2	September 1970	1,150	1977
	(Cowans Ford Dam, N.C.)			
Commonwealth Edison Co., et al.	LaSalle-1	November 1970	1,078	1975
	LaSalle-2	November 1970	1,078	1976
	(Seneca, Ill.)			
Puerto Rico Water Resources Authority.	Aguirre (Central Aguirre, P.R.).	November 1970	660	1976
Louisiana Power and Light Co	Waterford-3	December 1970	1,165	1976
	Waterford-4	December 1970	1,165	1977
	(Taft, La.)			

[1] Applications inactive.
[2] Postponed indefinitely by applicant.



A First-of-Its-Kind Nuclear Plant is shown by the model *above.* Consumers Power Co. of Michigan plans 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 will be about 1,310 Mwe., and about 4 million pounds per hour of process steam will be produced. Operation of the two units is projected for 1974 and 1975. Photo *below* is of a Bechtel Corp. model of the Portland General Electric Co.'s Trojan Nuclear Plant which will be built near Rainier, Ore. The nuclear portion of the plant will be a 1,130-Mwe. Westinghouse pressurized water reactor with the steam being condensed for recycling in the tower at *left.* Operation of the plant is scheduled for 1974.



80 applications were denied. At the end of 1970, 1,202 operator licenses and 836 senior operator licenses were in effect.

The AEC conducts advance certification examinations for persons who plan to apply for licenses to operate reactors. To qualify, a candidate must have about 6 months of training at an operating reactor comparable to the facility he expects to operate. If certified, he is eligible for a license examination at the reactor facility where he is to be employed. During 1970, the AEC issued certification letters to 33 applicants.

Licensed Reactor Exports

Three facility export licenses were issued in 1970, two of which authorized the export of power reactors to Japan. One, issued to Mitsubishi International Corp., authorized the export of a Westinghouse 500-Mwe. power reactor known as the Mihama Unit No. 2, and the other was issued to the General Electric Co. for the export of a 760-Mwe. power reactor known as Fukashima II. A license was issued to Gulf Energy and Environmental Systems, Inc., for the export of a 2-Mwt. TRIGA Mark II research reactor to Seoul, Korea.

PRACTICAL VALUE CONSIDERATION

On December 19, 1970, legislation was enacted to amend the Atomic Energy Act which, among other things, eliminates the requirement for a finding of "practical value" by the AEC before nuclear facilities (such as power reactors and fuel reprocessing plants) can be licensed under the "commercial section" (section 103) of the law. Amendments to AEC regulations to reflect P.L. 91–560 were placed in effect December 29, 1970.[13]

Since the Commission had not made a finding that such nuclear facilities had sufficiently demonstrated their practical value for industrial or commercial purposes—although it has been under consideration [14]—all nuclear power reactors and fuel reprocessing plant licenses

[13] Amendments to 10 CFR Parts 2 and 50, published in *Federal Register* December 29, 1970, effective on publication. See Appendix 4, "Rules and Regulations."

[14] A practical value rule making proceeding initiated by the AEC by notice of June 26, 1970, was terminated by notice published on December 29. On two past occasions, the Commission has considered the matter, and concluded each time that a finding could not be made on the basis of cost information limited to the prototype and noncompetitive nuclear power reactors then in operation. (See pp. 17–18, "Annual Report to Congress for 1965," and p. 433, "Annual Report to Congress for 1966.")

had been issued under the research and development section (104 b.) of the Act until enactment of the new legislation. Such licenses now will be issued under section 103, with the exception of reactors in the AEC's Power Demonstration Program and facilities specifically authorized by the law for 104 b. licensing. All facilities already licensed under section 104 b. will continue to be licensed under that section.

One of the principal effects of licensing under section 103 is that applications for facilities for commercial or industrial purposes are subject to antitrust review by the Attorney General and the Commission. Provision is made in AEC regulation changes for hearings on antitrust matters where appropriate, which would generally be held separately from hearings on radiological safety matters. Also, notice of application must be published for four consecutive weeks in the *Federal Register*, and notice must be given to various regulatory agencies and others.

Another requirement is that the AEC may not waive charges for use of source and special nuclear material for section 103 licensees, and charges must be made for consumption of nuclear fuel.

SAFETY CRITERIA AND STANDARDS

During 1970, the AEC and industry intensified joint efforts to develop comprehensive standards programs for light water cooled and moderated power reactors. Regulatory staff reorganizations assured that specialists in all important disciplines were available to develop safety-related standards. Technical societies (for example, the Institute of Electrical and Electronics Engineers, the American Society of Mechanical Engineers, and the American Nuclear Society) have reorganized key standards bodies and steering committees to set priorities for the early development of needed reactor standards.

Quality Assurance Criteria

On June 27, the AEC published in the *Federal Register*, "Quality Assurance Criteria for Nuclear Power Plants" as Appendix B to 10 CFR Part 50. Originally issued in April 1969 for public comment and interim guidance, the criteria take into account a number of comments and suggestions for improvement. These criteria cover the design, construction, and operation of the safety-related aspects of certain reactor structures, systems, and components from their design through their operating life. These requirements for quality assurance of nuclear powerplant safety-related features are expected to further enhance the overall safety of nuclear powerplants.

Nuclear Powerplant Safety Guides

Late in the year, the AEC began making available a series of safety guides [15] to assist the nuclear power industry in determining the acceptability of specific safety-related features of light water-cooled nuclear powerplants.

While general guidance on acceptability of design features is provided in AEC regulations, detailed guidance has not been established in a number of areas, and regulatory decisions have been made on a case-by-case basis in licensing actions. The new guides, while not containing mandatory requirements, are intended to indicate positions developed by the AEC regulatory staff and the Advisory Committee on Reactor Safeguards (ACRS) in these safety areas and describe principles and specifications that will represent acceptable solutions.

Four guides completed by yearend include:

(*1*) "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps."
(*2*) "Thermal Shock to Pressure Vessels."
(*3*) "Assumptions for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors."
(*4*) Same as (*3*) above, but for boiling water reactors.

More than a dozen other guides are being prepared or planned.

Emergency Plans

On May 21, the AEC published in the *Federal Register* proposed minimum requirements for emergency plans for nuclear reactors or other facilities, such as fuel reprocessing plants. Following receipt and consideration of comment, these requirements were published as an effective rule on December 24, 1970. In addition, a guide for emergency plans was made available.[16] All nuclear facility licensees are required to develop well-defined emergency plans for coping with the potential consequences of a significant facility accident. These plans are reviewed on a case-by-case basis in the licensing process. The guide is expected to aid prospective licensees in the development of such plans, to result in more uniform and definitive procedures, and to facilitate the licensing process in this area.

---

[15] Copies of the guides may be obtained by writing to the Director, Division of Reactor Standards, U.S. Atomic Energy Commission, Washington, D.C. 20545.

[16] The guide to assist in developing emergency plans is available for inspection in the AEC's Public Document Room, 1717 H Street NW., Washington, D.C., and from the Divisions of Reactor Licensing and Materials Licensing, USAEC, Washington, D.C. 20545.

Backfitting Requirements

On March 31, the AEC published effective amendments to its regulations which: (*a*) Provided that the AEC will require imposition of additional safety requirements after issuance of a facility construction permit when it finds that such backfitting will provide "substantial additional protection" required for public health and safety, and (*b*) eliminated the word "provisional" from construction permits and operating licenses.[17]

Fuel Loading and Low-Power Testing

In order to expedite the licensing process without adversely affecting public health and safety, the AEC in October published proposed amendments of its regulations concerning initial fuel loading and low-power testing of nuclear powerplants.[18]

One proposed change would provide authorization under the construction permit for initial fuel loading of a power reactor without attainment of a nuclear chain reaction, provided it is shown that public health and safety would not be compromised.

The other proposed amendment would clarify and codify in AEC regulations the fact that an atomic safety and licensing board (ASLB) may consider and act upon a request for a license authorizing low-power testing, while a licensing proceeding on the issuance of an operating license is pending. ("Low-power testing" operations are conducted at not more than one percent of full power.)

The proposed amendments would also provide for immediate effectiveness of ASLB initial decisions authorizing issuance of operating licenses, as is now the case with such decisions on construction permits.

Radioactivity Releases to the Environment

On December 3, the AEC published in the *Federal Register* amendments to its regulations, effective January 2, 1971, to improve the regulatory framework for assuring that reasonable efforts are made to continue to keep exposures to radiation and releases of radioactivity in effluents from power reactors as low as practicable. In adopting the effective amendments, the AEC made some changes as a result of many comments received on the proposed rule as published in the *Federal Register* in April. For example, the effective rule applies to all power

---

[17] Amendments to 10 CFR Parts 2, 50, 115 and 170, published in *Federal Register* on Mar. 31, 1970. (See Appendix 4 of this report.)

[18] Proposed amendments to 10 CFR Parts 2 and 50, published in *Federal Register* on Oct. 28, 1970. (See Appendix 4 of this report.)

reactors rather than only to light water cooled reactors as originally proposed.

While radioactivity releases from operating power reactors have generally been less than a few percent of limits in AEC regulations, and resultant exposures to the public in the vicinity of such plants have been small fractions of the Federal Radiation Council (FRC) radiation protection guides, the AEC's amendments are intended to give additional assurance that total radiation exposures from licensed activities remain low.

Technological progress has demonstrated increasingly that modern power reactors are capable of normal operation at levels far below the limits specified in the AEC's "Standards for Protection Against Radiation" (10 CFR Part 20). While the maximum limits set in Part 20 have not been modified, the effective amendments to this regulation and "Licensing of Production and Utilization Facilities" (10 CFR Part 50) are intended to encourage the employment of this technological progress in the design, construction, and operation of new nuclear power reactors. In addition, affected licensees will be required to submit semiannual reports to the AEC on radioactivity releases in effluents.

These new requirements augment the regulatory framework for assuring that radioactivity in effluent releases is indeed maintained as low as practicable with available procedure and equipment technology. They will assure further improvements in radioactivity control as advances in technology are made. At the same time, the effective amendments provide the necessary flexibility of operation, compatible with considerations of health and safety, to take into account unusual operating conditions, such as fuel element cladding failures, that may temporarily result in levels of radioactivity somewhat higher than the design objectives, but still well within Part 20 limits and FRC radiation protection guides.

The Part 20 limits are based on the numerical radiation protection guides recommended by the FRC and approved by the President, for the guidance of all Federal agencies in the formulation of radiation standards. Any future changes made in these guides will, of course, be reflected in changes in Part 20.

The AEC has announced plans to consult with the nuclear power industry and others concerning possible development of more definitive criteria for design objectives and means for keeping effluents from nuclear power reactors "as low as practicable."

REGULATION OF MATERIALS

The prospect of increasing numbers of operating nuclear powerplants has stimulated industry activities in the nuclear fuel cycle, including uranium mills, fuel processing and fabrication plants, and facilities for recovering uranium and plutonium from "spent" (irradiated) reactor fuel elements. Such activity has, necessarily, increased regulatory activities relating to the health and safety evaluation of proposals to build and operate these facilities. The packaging, transportation and disposal of radioactive materials also are regulated.

In 1970, a fuel fabrication plant and a uranium processing plant were licensed, a construction permit was issued for a third spent fuel reprocessing plant, and an application review was started for a fourth. In addition, the year witnessed the establishment of AEC policy on the siting of irradiated fuel reprocessing plants and on long-term disposal of the high-level radioactive wastes produced in the reprocessing.

Outside the fuel cycle, the licensed use of uranium, thorium, plutonium and radioisotopes in industry, commerce, medicine, and education continued to increase under the regulatory programs of both the AEC and the 22 States which have entered into regulatory agreements with the AEC.

NUCLEAR FUEL CYCLE ACTIVITIES

In February, the AEC licensed the Kerr-McGee Corp. to convert uranium concentrates ("yellowcake") to uranium hexafluoride at its new plant near Gore, Okla. The plant, located on a 1,500-acre site, has a nominal design capacity to convert 5,000 tons of yellowcake annually, but can be easily expanded to handle 15,000 tons a year.

Fuel Fabrication Plants

Kerr-McGee was also licensed to operate a plutonium fuel fabrication plant constructed adjacent to its enriched uranium plant near Crescent, Okla. The facility, which will fabricate uranium-plutonium oxide fuel elements, is designed to recover plutonium from scrap and wastes generated in the processes.

The Jersey Nuclear Co. (a division of Jersey Enterprises, Inc., and wholly owned affiliate of Standard Oil Co. of New Jersey) applied for a license for its plant at Richland, Wash., to fabricate uranium fuel elements using uranium hexafluoride as the starting material. The firm is also constructing a plant at the same site for research and development on mixed plutonium-uranium oxide fuel elements.

Fuel Reprocessing Plants

Nuclear Fuel Services, Inc., announced plans to modify and expand its West Valley, N.Y., facility over the next 5 years. The plant, which is the Nation's first privately owned irradiated reactor fuel reprocessing plant, has been operating since April 1966. Plans involve improved radiation and contamination control, reductions in radioactivity in liquid and gaseous wastes, and expansion of feed preparation facilities and plutonium purification operations.

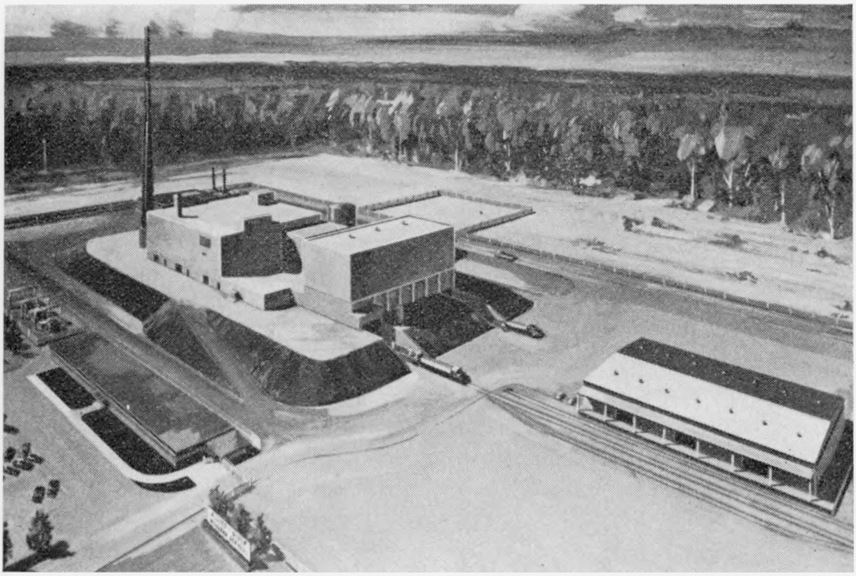
During the year, 40 actions were taken to issue, renew, or amend licenses authorizing individuals to operate controls of the NFS West Valley reprocessing plant.

Construction continued during the year on General Electric Co.'s Midwest Fuel Recovery Plant near Morris, Ill., which is scheduled to be the second privately owned fuel reprocessing plant to be placed in operation. The latest completion date shown in the construction permit was extended to July 1, 1971. The plant, when in full operation, is

As Nuclear Fuel Cycle Activities continue to expand—one new fuel fabrication facility and a uranium hexafluoride (UF_6) plant were licensed by the AEC in 1970—research and development on packaging and the safe transportation of nuclear materials continues. Photo *above* is of several protective shipping packages for UF_6 cylinders. These packages and their high temperature phenolic resin foam insulation were developed at the Oak Ridge Gaseous Diffusion Plant to meet AEC and Department of Transportation (DOT) requirements for protection against accident, fire, and water immersion. Prototypes successfully withstood 30-foot drop tests and 1-hour diesel oil fire tests at temperatures to 2,100° F.

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. It was 76 percent complete at the end of 1970.

Allied Chemical Nuclear Products, Inc. and Gulf Energy and Environmental Systems, Inc., have formed a partnership (Allied Gulf Nuclear Services) to construct and operate the third privately owned fuel reprocessing plant. A construction permit was issued by the AEC on December 18, 1970, following a public hearing conducted by an atomic safety and licensing board in Barnwell, S.C., on October 20–21. This facility, to be known as the Barnwell Nuclear Fuel Plant, is contiguous with the east boundary of the AEC's Savannah River Plant site. It is designed for a daily throughput of 5 metric tons of spent power reactor fuel and will provide for the recovery of neptunium, in addition to plutonium and uranium. Construction is expected to be completed in 1973 and commercial operation is scheduled for 1974.



A Construction Permit for the Barnwell Nuclear Fuel Plant was issued by the AEC in December 1970. The plant will be constructed and operated by Allied-Gulf Nuclear Services, a joint subsidiary of Allied Chemical Nuclear Products, Inc., and Gulf Energy and Environmental Systems, Inc. This is the third investor-owned irradiated fuel reprocessing plant (artist's sketch *above*) to be authorized for construction. It will be located on a site contiguous with the east boundary of the AEC's Savannah River Plant site, about 7 miles west of Barnwell, S.C., and is designed to handle 5 metric tons of "spent" power reactor fuel daily and recover neptunium. Earliest completion date provided in the permit its January 1, 1973, and latest, 1 year later.

On October 29, Atlantic Richfield Co. submitted a construction permit application for a reactor fuel reprocessing plant to be located near Leeds, S.C. The plant also will be designed for a daily throughput of 5 metric tons of uranium in irradiated fuel, and will provide for separation of neptunium as well as uranium and plutonium from the spent fuels. The scheduled operational date is mid-1976.

Reprocessing Plant Siting

During the year, the AEC amended its licensing regulations (10 CFR Part 50) to establish a policy governing the siting of reprocessing plants for irradiated fuel from nuclear reactors and the disposal of high-level radioactive liquid wastes generated at the plants. Principal provisions of the policy statement are: (*a*) Public health and safety considerations associated with fuel reprocessing plants do not require their location on Federally-owned or controlled land, and (*b*) high-level radioactive liquid wastes produced in chemically reprocessing irradiated fuels must be converted to an AEC-approved solid form within 5 years and shipped to a Federal repository for permanent disposal no later than 10 years after the fission products are separated from the irradiated fuel. The policy statement, published in June 1969 for public comment, was issued in revised form to become an effective rule on February 12, 1971.[19]

Byproduct Materials

The AEC receives more than 7,000 applications annually for new licenses and amendments or renewals of licenses for the possession and use of byproduct materials (reactor-produced radioisotopes). The number of effective AEC radioisotope licenses increased moderately in 1970, totaling about 7,500, and held by about 5,600 licensees. Nearly half of these were industrial, more than one-third medical, and the remainder distributed among educational and training users.

Medical Licenses

The AEC's Advisory Committee on the Medical Use of Isotopes evaluated and approved—as well-established diagnostic procedures—the uses of iodine-131 as iodinated human serum albumin for studies of cranial fluid spaces and technetium-99m as pertechnetate for de-

---

[19] Proposed policy statement published in *Federal Register* June 3, 1969. Effective rule published in *Federal Register* on Nov. 14, 1970.

termining the amount of blood in selected body areas or organs, salivary gland scans, and placenta localization.

A license authorizing operation of an irradiation facility to sterilize packaged medical products was issued to Becton-Dickinson & Co., North Canaan, Mass. The facility uses 210,000 curies of cobalt-60 in a water-shielded irradiation cell.

Class Exemptions

Honeywell, Inc., Minneapolis, Minn., was licensed to distribute fire detection devices containing up to 1 millicurie of nickel-63 to persons exempt under the AEC class exemption for gas and aerosol detectors. The devices are designed to detect incipient fires by responding to the decomposition products of flammable materials preceding smoke, flame, or appreciable heat. Honeywell is the second manufacturer to be licensed for exempt distribution of such devices. In 1968, Pyrotronics, Inc., Cedar Knolls, N.J., was licensed to distribute a similar device containing up to 130 microcuries of americium-241.

Industrial Radiography Safety

Several steps are being taken to encourage improved safety in industrial radiographic operations. During 1970, AEC regulations were amended to require radiography licensees to provide for inspection and maintenance of their radiographic equipment.[20] The AEC regulatory staff also continued to work with radiographic equipment manufacturers to encourage improvements in equipment design. Devices are being designed to prevent the inadvertent exposure of improperly connected radioisotopic sources, a recognized safety problem in the radiography industry. In addition, the AEC is cooperating with industry standards groups in the preparation of a manual of good practice for radiographers.

Export of Materials

During the year, the AEC issued 258 specific licenses which authorized the export of byproduct, source, and special nuclear material from the United States. Of these, 21 licenses were issued which permitted the export of byproduct and source material to the Eastern

---

[20] Proposed amendment to 10 CFR Part 34 was published for comment in the *Federal Register* on June 26, 1970; and the final rule, published on Nov. 13, 1970, became effective Dec. 13, 1970.

European countries, and 97 licenses were issued for the export of special nuclear material to 15 countries.

STATE REGULATORY AGREEMENTS

During 1970, several States continued to prepare for agreements with the AEC under section 274 of the act, whereby the State would assume regulatory authority over byproduct, source, and small quantities of special nuclear materials.

By the end of 1970, there were 22 States operating under agreements with the AEC,[21] and all but six of the remaining States had enacted enabling legislation for such agreements. An agreement was executed with the 23d State, Maryland, on December 18, 1970, to become effective on January 1, 1971.

The number of licenses being administered by the States at yearend was about 7,650 as compared to approximately 8,500 licenses for similar materials being administered by the AEC.

Post-Agreement Cooperation with States

After agreements are signed, the AEC and States continue to work together in order to maintain compatible regulatory programs. The post-agreement cooperative program involves the exchange of information on regulations, licensing, inspection and enforcement, and consultation on special regulatory problems. Periodically, the AEC meets with State representatives to review the State's regulatory program and to discuss regulatory policies and practices. In addition, an annual meeting of all agreement States is held to discuss matters of common regulatory interest. As a result of its formal 1970 annual review, the AEC made the finding that the regulatory programs of the 22 agreement States continued to be adequate to protect health and safety and were compatible with the AEC's program for regulating nuclear materials.

Training for State Personnel

A 10-week training course was conducted by the AEC at Oak Ridge in 1970 to assist State personnel in building and maintaining pro-

[21] Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Kansas, Kentucky, Louisiana, Mississippi, Nebraska, New Hampshire, New York, North Carolina, North Dakota, Oregon, South Carolina, Tennessee, Texas, and Washington.

ficiencies in health physics and radiation protection. One-week training courses in the medical use of radionuclides were conducted for States by Baylor College of Medicine, and Johns Hopkins Medical Institution. Another 1-week course in the health and safety aspects of industrial radiography was given at Louisiana State University.

A total of 61 State personnel, representing 30 different regulatory agencies, attended these courses. Two orientation courses on regulation and licensing policies and procedures also were presented at AEC's Bethesda, Md., office in which a total of 27 persons participated from 17 different States.

COMPLIANCE AND ENFORCEMENT

During 1970, AEC personnel performed 1,135 inspections of activities conducted under materials licenses and 627 inspections of reactor facilities. In 3.5 percent of the inspections of materials licenses and 2.9 percent of the inspections of operating reactors, the AEC inspectors found items of noncompliance with regulatory requirements that required formal AEC enforcement action.[22] There were no orders to modify, suspend, or revoke a license.

Safety in Atomic Energy Industry

The fifth annual U.S. Bureau of Labor Statistics survey of injury frequency and severity rates covering 1969 data, once again showed work-injury experience in the atomic energy industry, to be better than recent averages for all manufacturing industries. In 1969, atomic energy employees experienced an injury frequency rate of 5.2 disabling injuries from all causes for each million man-hours worked (down from 6.7 in 1968) and an injury severity rate of 303 days lost for each million man-hours worked. By comparison, the rates for all manufacturing were 8.1 injuries and 730 days for each million man-hours worked.

Radiation Exposure Statistics

The AEC continued to obtain statistical information on radiation exposures to licensee employees. Through contacts with two leading commercial film badge companies, the AEC received 1969 summaries on licensee-employees film badge readings. The data covered about 29

[22] AEC regulations (10 CFR Part 2 Subpart B) provide for enforcement actions in the form of issuance to licensees of notices of violations and orders to modify, suspend, or revoke a license.

percent of AEC licensees and about 62,090 of their employees. Very low levels of exposure were generally indicated. The badges of 95.8 percent of the employees showed an exposure of less than 1 rem [23] during 1969, and the badges of 74 percent of all employees showed an exposure of less than 0.1 rem for that year. AEC regulations (10 CFR Part 20.407) require that certain categories of licensees report annually all individual exposures in excess of 1.25 rems per year.

Radiation Incidents

During the year, 17 radiation incidents were reported by AEC licensees as required by the regulations.[24] 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.

Two of these 17 incidents occurred during radiographic testing (nondestructive testing or inspection) operations, and involved personnel exposures. Four incidents involved malfunctioning hospital teletherapy devices, and three of which resulted in personnel exposures. Two other incidents resulted from malfunctioning irradiation equipment, and one from improper handling of an irradiation capsule in a research reactor operation. The maximum exposures were about 4,000 rems to the hands of three teletherapy workers. The highest whole-body exposure was 31 rems, also to a teletherapy worker. Failure to properly maintain teletherapy devices and to make adequate radiation surveys led to most exposures. Seven other incidents involved the spread of contamination, resulting in temporary loss of facility use, but no releases to uncontrolled areas or personnel over-exposures.

Lost Radioactive Material

During 1970, AEC licensees reported 42 losses of radioactive material. In 19 of these instances the missing material was subsequently recovered with no apparent radiation hazard to the public. In those instances where the material was not recovered, 15 losses occurred in inaccessible locations, and eight were losses of small quantities of radionuclides not constituting a hazard to the general public.

---

[23] *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.

[24] Licensees are required to report to the AEC significant radiation incidents which occur in licensed operations. each of which is investigated. Licensee reports on all such incidents are filed for public inspection in the AEC's Public Document Room, 1717 H Street NW., Washington, D.C.

REACTOR INSPECTION PROGRAM

Field compliance inspections of reactor facilities are conducted as an important part of the AEC's regulatory program during the construction, test and startup, and operation phases, to verify that AEC regulatory requirements are being met. The 627 inspections of reactor facilities during 1970 involved a total of 189 reactors, consisting of 85 inspections of power reactors, and 104 on test and research reactors.

Quality Assurance Inspections

Regulatory inspections have been expanded to include examination of the manner in which various licensees were developing programs consistent with the AEC's "Quality Assurance Criteria for Nuclear Power Plants" since publication of the criteria in proposed form in mid-1969. A formal program for inspection of licensees' quality assurance programs was established when the rule change became effective in June 1970.

Vendor Inspections

Inspections continued of vendors supplying components for reactors under construction to evaluate the safety and quality of the products, determine compliance with the specified codes and standards, and to evaluate quality assurance provisions of the manufacturing systems. Reactor pressure vessels received the highest priority in this effort. The principal suppliers of primary coolant pumps, valves and primary system piping were also inspected on a regular basis.

In addition to four U.S. firms fabricating reactor vessels or major associated components, five foreign firms are now fabricating pressure vessels for U.S. power reactors, with a total of 16 vessels involved. During 1970, four additional orders were awarded to the Rotterdam Dockyard Co., The Netherlands. An order for one vessel and an option for a second were given to Hitachi, Ltd., Tokyo, Japan, the first U.S. order for this company. AEC inspection teams continued to inspect the foreign vessel suppliers on a similar basis to the program established for the domestic suppliers. Each of the six sites of the four domestic fabricators[25] and four of the five foreign companies were inspected during 1970. The foreign companies inspected were: Rotterdam Dockyard Co. in The Netherlands; Sulzer Brothers, Ltd., Winter-

[25] Babcock & Wilcox, Mt. Vernon, Ind., and Barberton, Ohio; Chicago Bridge & Iron Co., Memphis, Tenn., and Birmingham, Ala.; Combustion Engineering, Chattanooga, Tenn.; and Westinghouse Electric Corp., Tampa, Fla.

412-406—71——8

thur, Switzerland; Societe des Forges et Ateliers du Creusot, Le Creusot, France; and Ishikawajima-Harima Heavy Industries Co., Ltd., Yokohama, Japan.

ENVIRONMENTAL SURVEILLANCE ACTIVITIES

The AEC continued to collect and review data on effluent releases from operating power reactors and expanded its program of independent verification of controls over such releases and associated environmental surveillance to other major licensed facilities. These activities supplement review of environmental sampling programs conducted periodically by licensees.

Data for 1970 indicated that radioactivity in effluent releases from licensed nuclear facilities continued to be well within limits set by AEC regulations.

Independent Measurements and Sampling

A program of independent measurements of radiation levels and concentrations of radioactivity around typical licensed operations, begun in 1967, was expanded during the year to include a pressurized water reactor facility (Indian Point Station, N.Y.). Similar programs were continued at a boiling water reactor (Humboldt Bay, Calif.); an irradiated fuel reprocessing plant, a fuel scrap recovery and processing plant (Nuclear Fuels Services at West Valley, N.Y., and Erwin, Tenn., respectively); and a large-scale radioisotopes production facility (Mallinckrodt Chemical Works, St. Louis, Mo.). Results of these programs are provided to the licensee, the State in which the plant is located, and the U.S. Public Health Service.

Soil, water and stream sediment studies around major plutonium processing facilities were begun in 1970 to obtain independent data on background levels of plutonium in the environment and on any changes attributable to facility operation.

Annual sampling of inplant waste streams at all operating power reactors also was initiated during the year. This program, which will provide further information on the isotopic composition and magnitude of airborne and liquid wastes generated before dilution and release, will audit the licensees' control practices and the adequacy of release evaluations.

As an important adjunct to regulatory evaluation of the types and quantities of radioactive materials released to the environment from nuclear plant operations, aerial surveys were conducted at eight licensee sites during 1970, making a total of 25 sites for which such surveys have been completed. These Aerial Radiological Measuring Systems (ARMS) surveys[26] use sensitive instrumentation for wide-area surveillance capability. Many were conducted at construction sites to determine background radiation levels in order that subsequent overflights during plant operations can detect any potential changes.

Cooperative Monitoring Programs

During 1970, the AEC developed a cooperative program under which individual State agencies would conduct for the AEC under contractual arrangements various monitoring activities in the vicinity of operating nuclear facilities within the State. These arrangements would include financial support where needed and technical assistance, and would provide for collaboration with the AEC in collecting and evaluating environmental data. A contract was executed on November 5, 1970, with Pennsylvania for conducting certain inplant and offsite radiological monitoring at power reactor installations in that State. Similar plans were discussed with officials of New York and Maryland. The AEC is cooperating with the Environmental Protection Agency (EPA) in the development of environmental surveillance guides for various types of nuclear plants sites.

INDEMNIFICATION AND INSURANCE

At yearend, there were 104 indemnity agreements in effect with AEC licensees. These agreements cover the licensed operation of 22 power reactors, 76 research reactors, 5 testing reactors, 11 critical facilities, one fuel reprocessing plant, operation of the NS *Savannah*, the storage of nuclear fuel prior to operation of a reactor at 14 sites, and one construction permit.

During 1970, $562,455 was earned by the AEC in indemnity fees.[27] Fees earned since the inception of the program totaled $1,787,138 as of December 31, 1970.

Refunds of Insurance Premiums

As a further reflection of the continued favorable safety record of the nuclear industry, the Nuclear Energy Liability Insurance Asso-

[26] The ARMS surveys are conducted for AEC by EG & G, Inc., Las Vegas, Nev.

[27] The annual indemnity fee is $30 per thermal megawatt for licensed reactors, subject to a minimum charge of $100.

ciation (NELIA) and the Mutual Atomic Energy Liability Underwriters (MAELU) made refunds of premium reserves in 1970 to the 1960 holders of private nuclear liability insurance policies. This was the fourth 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. Refunds totaled $784,612, representing 67.2 percent of the total premiums paid in 1960 by the policyholders and 96.4 percent of the reserve established from these premiums.

AEC LICENSE FEES

License fees paid to the AEC during 1970 totaled $472,473, bringing to $1,069,113 the amount collected since fees were first imposed on October 1, 1968.

On August 4, 1970, the AEC published in the *Federal Register* proposed amendments to its regulations for public comment which would increase license fees charged by the AEC, and expand the fee schedules to cover additional materials licenses. The rule making action had not been completed by yearend.

Chapter 4

SOURCE, SPECIAL, AND BYPRODUCT NUCLEAR MATERIALS

Basic to the Nation's overall atomic energy program, are the source, special, and byproduct nuclear materials—the uranium that exists as a natural resource; the uranium that has had its fissionable potential enhanced by the enrichment process; the plutonium that is created by the uranium fissioning within a reactor; the radioisotopes that can be made from plutonium by long-term transmutation; and the radioactive materials that can be recovered from "spent" reactor fuels. Because the special nuclear materials—uranium-233 and -235, and plutonium-239—can be used in nuclear weapons, they must be safeguarded against diversion to unauthorized use. First undertaken solely to meet an urgent Government military requirement, the mining, processing, using—and, in recent years, the reprocessing for further use—of nuclear materials have now, in a little more than two decades evolved into a private industry with sales of a little more than a quarter of a billion dollars in 1970 as the AEC has continued to phase out its activities in these areas.

URANIUM SUPPLY

Exploration activity was 20 percent below the record 1969 levels, but 1970 additions to ore reserves approximated those of 1969. The AEC closed out uranium procurement at yearend;[1] over the past 24 years, the AEC has purchased 316,000 tons of U_3O_8 in uranium concentrates from domestic and foreign sources. The AEC's 1947–70 procurement of uranium is summarized in the chart on the next page.

[1] See p. 84, "Annual Report to Congress for 1966."

RAW MATERIALS

Uranium Procurement

During 1970, the AEC purchased 2,500 tons of U_3O_8 in domestic uranium concentrates. The estimated production totaled 12,000 tons. The price per pound of U_3O_8 delivered to the AEC in 1969–70 was estimated at $5.78. Deliveries under existing contracts will be completed early in 1971, and the AEC plans no further purchases of uranium.

Commercial Activity

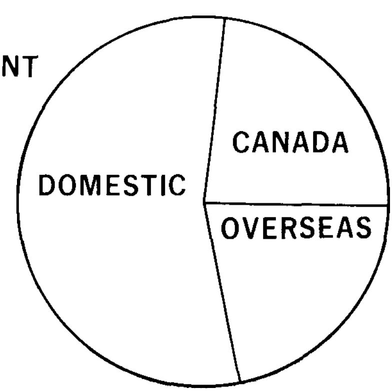
U.S. uranium producers delivered to commercial buyers 11,200 tons of U_3O_8 in 1970, including 1,900 tons destined for use in foreign reactors. Orders as of December 1, 1970, for uranium to be delivered in the years 1971–89, as shown in Table 1, are about 81,800 tons including 1,900 tons for overseas customers. Deliveries for the period 1966–1970 for domestic use were about 19,200 tons, well in excess of requirements for the period.

Some consumers have substantial uranium inventories as a result of delays in reactor construction, and the immediate uranium sales out-

AEC URANIUM PURCHASES

CY 1947 - 1970 – SHORT TONS U_3O_8

SOURCE	TONS	PERCENT
DOMESTIC	174,500	55
CANADA	73,800	24
OVERSEAS	67,600	21



U.S. PRODUCERS COMMERCIAL SALES 1966-1970

	TONS U_3O_8	PERCENT
DOMESTIC BUYERS	19,200	82
FOREIGN BUYERS	4,100	18

look is limited. Further, a number of recently discovered ore deposits could be brought into production in 2 or 3 years if warranted by uranium demand. It appears that the market will continue to be soft for several years.

American Metal Climax, Inc. closed its mill in Grand Junction, Colo. However, Susquehanna-Western, Inc., started up a new mill at Ray Point, Tex., and Dawn Mining Co., reopened its mill at Ford, Wash. The new Utah Construction & Mining Co. mill at Shirley Basin, Colo., was ready to start up at yearend and Rio Algom began construction of a new mill near Moab, Utah. In 1972, both Humble Oil Co., and Continental Oil Co. will bring new plants into operation. By the end of 1972, there will be 21 mills [2] in operation with a production capacity of 19,000 tons of U_3O_8 per year.

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

(In tons U_3O_8)

Year	Delivery commitments		Projected requirements	
	Annual	Cumulative	Annual	Cumulative
1971	12,300	12,300	6,900	6,900
1972	11,200	23,500	10,200	17,100
1973	11,600	35,100	14,000	31,100
1974	10,200	45,300	16,700	47,800
1975	10,800	56,100	18,400	66,200
1976	4,700	60,800	21,100	87,300
1977	4,800	65,600	24,400	111,700
1978	4,200	69,800	28,600	140,300
1979	3,300	73,100	31,700	172,000
1980	2,300	75,400	34,200	206,200
Post-1980	6,400	81,800	245,900	452,100

Ore Reserves

A large volume of new ore reserve data was generated in 1970, reflecting the continued high rate of drilling. A preliminary analysis indicates that ore reserves containing 52,000 tons of U_3O_8 recoverable at $8 per pound were added to the reserves, while 13,000 tons were mined and delivered to mills in 1970. The resulting indicated net gain in $8 reserves at yearend was 39,000 tons, about the same as in 1969. The preliminary estimate of yearend reserves of 243,000 tons of U_3O_8 at $8 represents about an 11-year supply, adequate now, but not large in terms of projected long-range needs. To permit a better assessment

[2] For table listing older mills, see p. 38, "Annual Report to Congress for 1969."

Uranium Is Found mostly in deposits of uraninite, coffinite, and brilliantly colored minerals irregularly disseminated in sandstones of the Western States. About 4 pounds of uranium oxide is contained in an average ton of ore mined. Photo *above* shows a large backhoe excavating uranium ore from the open pit mine of the Petrotomics Co. in Shirley Basin, Wyo. The backhoe is better adapted to selective excavation of the ore than are larger excavators commonly used for removal of overburden. In the photo *below*, two men are dwarfed by the size of the 100-ton-capacity, electric-drive truck used to transport the great quantities of ore and waste that must be removed to obtain only a few pounds of uranium concentrate. A 1-pound ball of U_3O_8 would be slightly less than 2 inches in diameter.

of the domestic ore reserve position at the end of 1970, a final estimate of ore reserves as of yearend will be issued about April 1, 1971.[3]

	Tons of ore	Percent U_3O_8	Contained tons U_3O_8
Reserves Jan. 1, 1970	97,000,000	0.21	204,000
Reserves Dec. 31, 1970 *	115,700,000	0.21	243,000
Net change during 1970 *	18,700,000	0.21	39,000

*Preliminary figures.

Future Exploration Plans

A mid-1970 AEC survey of industry drilling plans indicated that the 1969 high rate of surface exploration and development drilling (30 million feet) would not continue. The projected drilling plans of 52 companies called for 24 million feet of surface drilling in 1970, and 78 million feet during the 4 years 1970 to 1973 at a total cost of $120 million, excluding land acquisition and exploration rights. Actual drilling during 1970 was about 23.5 million feet. Despite the long-term projections of high demand for uranium in the late 1970's and 1980's, the near-term soft market is discouraging heavy investments for exploration and development. Of reported drilling plans for the next 4 years, 50 million feet is for exploration of new deposits, and nearly 28 million feet is in preparation for mining.

Plans for Leasing AEC Controlled Mineral Lands

Domestic Uranium Program Circular 8, Revised, was published on November 10, 1970, in the *Federal Register* for public comment in preparation for resumption of leasing certain lands in uranium mining areas which are controlled by the AEC. The circular provides the general guidelines to be used for leasing lands for mining, including the basis for competitive bidding procedures for award of leases. The total area (about 40 sq. mi.) available for leasing is comprised of many separate tracts most of which are scattered throughout the Uravan mineral belt in western Colorado. A few are located in eastern Utah and northern New Mexico. Except for a few tracts originally acquired from the Manhattan Engineer District (the wartime predecessor to the AEC), these lands represent the remainder of more than 700 square miles of land that had been withdrawn for exploration by

[3] An AEC press release is planned.

the Government in 1948–54, the balance having since been restored to the public domain. The lands retained by AEC contain a number of ore deposits discovered and developed as a result of exploration conducted at AEC expense in the late 1940's and early 1950's. During the 1950's, when uranium was in short supply, over a million tons of ore were produced from leases on AEC lands. The leases were not renewed beyond March 31, 1962, because of the rapid development of new reserves by the mining industry, and the need, by then, to limit U.S. uranium procurement commitments. However, new ore sources are needed in the Uravan mineral belt now to augment existing reserves and permit continued operations in this mature mining area.

Enrichment of Foreign Uranium and AEC Surplus Disposal

At present, foreign uranium is not being accepted by the AEC for enrichment if the product is for domestic (U.S.) end-use. This restriction was established pursuant to subsection 161v of the Atomic Energy Act of 1954, as amended. The restriction is temporary and will be relaxed, and ultimately removed, when no longer required to maintain a viable domestic uranium mining and milling industry. Another factor of considerable potential influence on the domestic uranium market is the timing of the disposal of Government-owned uranium, equivalent to approximately 50,000 tons of U_3O_8 in concentrates, which is in excess of Government requirements as a result of earlier cutbacks in production of fissionable materials. Plans for resolution of these two matters were still under study at yearend.

URANIUM ENRICHMENT

On July 21, 1970, the AEC announced that it had dropped plans to set up a separate uranium enrichment directorate. The proposed directorate [5] would have been a separate organizational entity within the AEC established for conducting uranium enrichment activities. The July announcement also stated there were no actual plans to transfer the uranium enrichment facilities to industry.[6] During 1969, the President had announced that he believed that the facilities should be sold at such time as various national interests will best be served, including a reasonable return to the Treasury. The gaseous diffusion plants for uranium enrichment are currently operating at a relatively small fraction of their capacity.

[5] See pp. 42–43, "Annual Report to Congress for 1969."
[6] See pp. 43–44, "Annual Report to Congress for 1969."

TOLL ENRICHMENT

As authorized by the Private Ownership of Special Nuclear Materials Act of 1964, uranium enriching services [7] were made available starting January 1, 1969. Since that time, toll enriching has been the primary method used by both domestic and foreign companies to contract for their enriched uranium needs for power reactors.

Toll Enriching Services

During this second year of the toll enrichment program, the AEC received revenues of $104 million for 4 million separative work units [8] supplied to domestic ($70 million) and foreign ($34 million) customers. During the year, 14 contracts were signed with domestic customers and 14 contracts were signed with foreign customers. The AEC completed deliveries under 9 contracts, and at yearend there were 20 domestic and 23 foreign active contracts to provide approximately 81 million separative work units.

Before the enactment of private ownership legislation and the commencement of toll enriching services, distributions of enriched uranium to domestic customers for power reactor uses were carried out under leasing arrangements. In accordance with the schedule specified in the act [9] for the transition to private ownership of nuclear fuel, AEC terminated, on December 31, 1970, distribution by lease of enriched uranium for use in domestic power reactors. Ending distributions by lease is expected to increase the number of domestic toll enriching contracts signed during 1971.

In addition to the revenues from toll enriching services, the AEC received $25 million for supplying *in situ* (in place) toll enriching services. *In situ* is a method whereby a lessee may acquire ownership of leased enriched uranium by furnishing, as payment, appropriate amounts of uranium feed and dollars. Since all special nuclear material

---

[7] 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.

[8] 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.

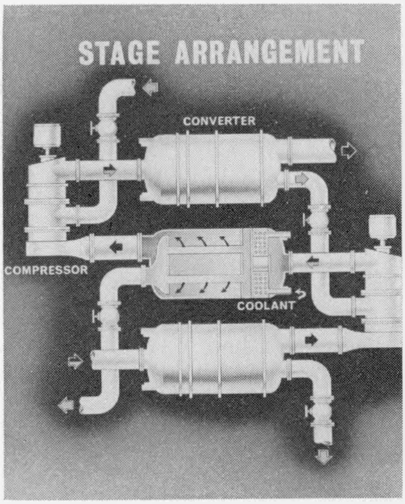
[9] See pp. 12–15, "Annual Report to Congress for 1964."

previously distributed by lease for use in power reactors must be converted to private ownership or returned to the AEC by June 30, 1973, *in situ* services will continue to be available until that date.

Increase in Charges

On August 25, 1970, the AEC announced an increase in its charge for uranium enrichment services from $26 to $28.70 per separative work unit, effective February 22, 1971. The previous charge of $26 had been in effect since January 1, 1968.

The AEC also announced on December 23, 1970, that it had submitted to the Joint Committee on Atomic Energy proposed new uranium enrichment services criteria based on provisions of the "Omnibus Bill" (various legislation concerning the AEC) which was signed December 19, 1970, by the President. At the same time, the AEC stated that the charge for enriching services on the basis of the amended criteria will be set at $32.00 per kilogram unit of separative work. This increase in the charge of $28.70 is necessary because of



The Gaseous Diffusion Process for enriching uranium is the only part of the nuclear fuel cycle not yet being done by private industry. The enrichment process is done at AEC-owned, contractor-operated gaseous diffusion plants in Kentucky, Ohio, and Tennessee. In the process, gaseous uranium hexafluoride (UF_6) is put through a series of barriers, which partially separate the highly fissionable, lighter and faster-moving uranium-235 atoms from the heavier and slower-moving uranium-238 atoms that make up the bulk of the material. Drawing on *right* shows the basic equipment required for the gaseous diffusion process. An electric motor drives each compressor which, in turn, compresses the UF_6 gas so it will flow through the porous membranes in each converter. A gas cooler in the converter removes the heat of compression. By following the flow stream, starting at *lower left*, it can be seen that the product stream from the bottom converter enters the central compressor and, after being partly compressed is mixed with the depleted stream from the top converter. This mixture is compressed still further and fed to the converter in the *center*. The product stream from this central converter moves to the next compressor upstream and the depleted stream is sent to the stage below. Groups of stages are coupled in this way to make up operating units and these units, in turn, make up a gaseous diffusion cascade.

increases in the projected costs of separative work, principally the cost of electrical power. It is expected that the $32.00 charge will become effective in the latter half of 1971.

NUCLEAR MATERIALS PRODUCTION

Production of special nuclear materials continued during 1970 at levels that were commensurate with scheduled requirements for military and civilian uses.

PRODUCTION OPERATIONS

Alternative plans for operation of the gaseous diffusion plants and the production reactors, to determine the best way to meet projected demands, continued to be evaluated. The existing enriched uranium capacity at Oak Ridge (Tenn.), Paducah (Ky.), and Portsmouth (Ohio), is sufficient to meet present needs. In anticipation of market growth in the late 1970's, power increases have been contracted for to provide additional uranium enriching capacity in existing plants. The first of these increases began on October 1, 1970, when 500 megawatts of seasonal power (October through May of each year) was delivered under the Electric Energy, Inc. (EEI) contract to Paducah. On April 15, 1970, the TVA contract was modified to increase the power at Oak Ridge by 200 megawatts starting in April 1976 and thereby raising the diffusion complex power under contract to an annual average of 4,633 megawatts.

During the year, another production reactor was placed in standby at the Hanford Works near Richland, Wash., where plutonium is the primary product, while the Savannah River production reactors (near Aiken, S.C.) continued to produce multiple products.

Gaseous Diffusion Plant Operations

During 1970, the total electric power usage level at the three AEC gaseous diffusion plants (Oak Ridge, Paducah, and Portsmouth) varied, in response to external conditions, from the schedules. The loss of generating capacity at the Tennessee Valley Authority (TVA) Paradise Plant, Drakesboro, Ky., coupled with a high winter demand within the TVA system, resulted in a power reduction of about 94 million kilowatt hours (kwh) during the period January 8 to 19. To compensate for this, TVA delivered slightly more than the contract demand during the period January 26 through June 24.

In May 1970, the Federal Office of Emergency Preparedness (OEP) made a study of the problems of electric power supply which showed that generating capacity to meet peak summer loads would be in tight supply in many areas of the East and Midwest. In cooperation with the OEP, and at the request of the utilities involved, the AEC agreed to the diversion of 450,000 kilowatts (kw.), beginning July 1. This diversion took 50,000 kw. from Oak Ridge and 300,000 kw. from Paducah effective through September 1, and 100,000 kw. from Portsmouth effective through September 30.

Because of a generator failure in the New York City area, an additional 200,000 kw. (50,000 kw. each from Oak Ridge and Portsmouth, plus 100,000 kw. from Paducah) was made available to Consolidated Edison Co. of New York, to alleviate a critical power shortage in the city during the period July 27–October 1. Then, to assist TVA in replenishing its coal stockpile at plants where a severe fuel shortage had occurred, a 150,000 kw. reduction in the TVA deliveries to Paducah was continued through October 31; this power is to be replaced by mid-1971.

Reactor Operations

On February 1, 1970, the Hanford "KW" production reactor was placed in standby status. It was the ninth production reactor to be shut down by AEC since early 1964. Five production reactors remained in operation—two at Hanford, and three at Savannah River—at year-end.[11]

Hanford Reactors

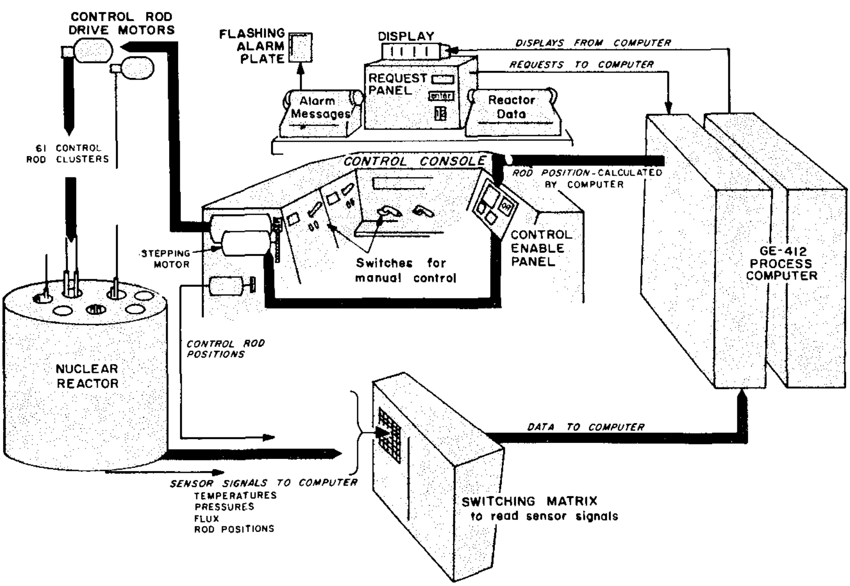
"N" Reactor Operation. Production of plutonium and byproduct steam for electric power generation continued at "N" reactor except for an extended outage of the reactor during the summer to continue the major planned maintenance program started in 1969. The byproduct steam from the "N" reactor is used in the adjacent Washington Public Power Supply System (WPPSS) generating station. During November, the facility set a new world record for electricity generation by a single-reactor plant of 511,820,000 kilowatt hours (kwh)—the previous

---

[11] The 1972 fiscal year (FY) budget sent to Congress by the President on January 29, 1971, provided for the shutdown of "KE" and "N" reactors— the last two remaining (of 9) production reactors at Hanford. The "N" reactor shutdown also results in termination of byproduct steam supply to the WPPSS (790-Mwe.) generating station. The FY 1972 budget provides for continued operation of the three (of 5) production reactors at Savannah River. (For previous shutdowns see "Annual Report to Congress for 1964," pp. 17–18; "1965," p. 73; "1966," pp. 90–92; "1967," p 36; "1968," p. 34; and "1969," p. 47.)

record, also held by the "N" reactor-WPPSS complex, had been the 502,220,000 kwh. generated in October 1969. An electric power output of about 2,700 million kilowatt hours was generated during 1970 to give a cumulative 4½-year output from the station of about 13,500 million kilowatt hours.

"KE" Reactor Operation. The KE reactor continued to produce plutonium-239, neptunium-237 and high-purity plutonium-238, as well as providing a wide variety of specialty irradiations for various Government programs.



Automatic Control of Reactor Operation is now achieved with an on-line computer at the AEC's Savannah River Plant where production reactor performance has been computer-monitored for 5 years. This extension of computer use is the first application in the United States of automatic control to a large, complex reactor. Upon operator request, the computer maintains or changes the power generated in the reactor by reading data from some 3,500 sensor signals and then adjusting control rod settings with stepping motors. In addition to controlling the overall power level, the computer moves groups of control rods individually to get the most effective power generation within the various regions of the reactor core. An unusual feature of the system allows control equations to adapt automatically to changes in the responsiveness of the reactor caused by fuel consumption, control rod effectiveness, and the buildup of fission products. The safety and productivity of reactor operation are improved with computer control; it has more cross checks than are used manually, it provides prompt response, and it minimizes the opportunity for human error.

Savannah River Reactors

Three Savannah River reactors continued to produce plutonium-239, tritium, neptunium-237, plutonium-238, and transplutonium elements, including californium-252.

Chemical Processing

During 1970, the AEC's chemical processing facilities at Savannah River, Hanford, and the National Reactor Testing Station (NRTS), Idaho, operated to process irradiated fuels from Government-owned reactors. At Hanford and Savannah River, the fuels processed were from the AEC's production reactors. The Chemical Processing Plant at NRTS processed irradiated fuels from U.S. and foreign research reactors and naval propulsion reactors.

Processing Charges

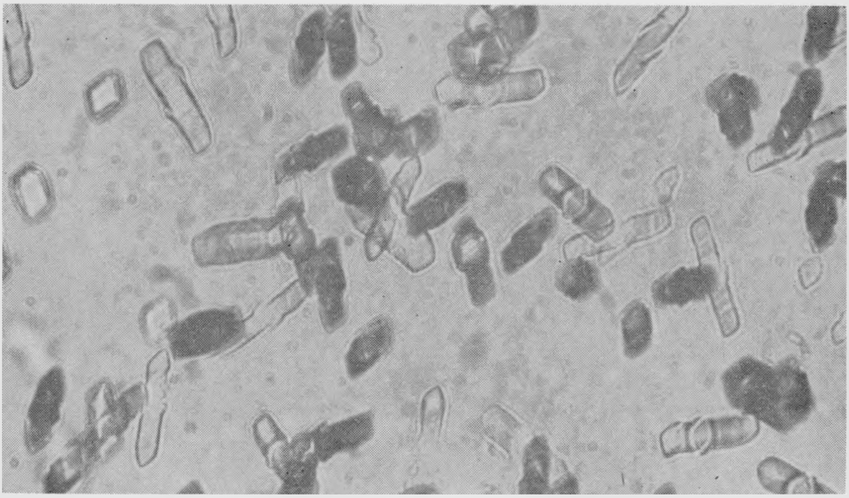
The AEC established, by publication in the *Federal Register* (June 4, 1970), processing charges (based on a conceptual processing plant [11]) for graphite-type reactor fuel discharged from high-temperature gas cooled reactors (HTGR). The AEC will accept these fuels for financial settlement until December 31, 1977, provided commercial services for their reprocessing are not available at reasonable terms and conditions. The daily charge established in a study by Idaho Nuclear Corp., the present operating contractor for the Idaho Chemical Processing Plant, for operating the conceptual plant would be $130,000 per day as of July 1969, the basic starting date for the charges. The study included a conceptual plant design, capital and operating cost estimates, return on equity capital and interest on borrowed capital.

The $130,000 daily charge, subject to escalation adjustment, will be used for making financial settlement with HTGR reactor operators under a policy in which the AEC agrees to receive private irradiated fuels and make financial settlement provided commercial processing services are not available at reasonable terms and charges. Core I from the Peach Bottom reactor (Philadelphia Electric Co.) will be the first fuel to be received by the AEC for financial settlement based on the HTGR conceptual processing plant.

[11] WASH–1152, "AEC Conceptual High Temperature Gas-Cooled Reactor (HTGR) Fuel Processing Plant," available from National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151, for $3. (This facility was previously called "Clearinghouse for Federal Scientific and Technical Information.")

Processing of Research Fuels Extended

The AEC also established processing charges for uranium-zirconium hydride research fuels in a *Federal Register* notice on December 1, 1970. The charges established for chemical processing of aluminum-clad uranium-zirconium hydride and stainless steel-clad uranium-zirconium hydride fuels were, respectively, $160 and $145 per kilogram of total fuel weight. Since commercial processing for enriched research fuels remain unavailable, the AEC has extended this service from December 31, 1970, to December 31, 1977. The AEC will provide a disposal service for uranium zirconium hydride spent fuel for $20 per kilogram



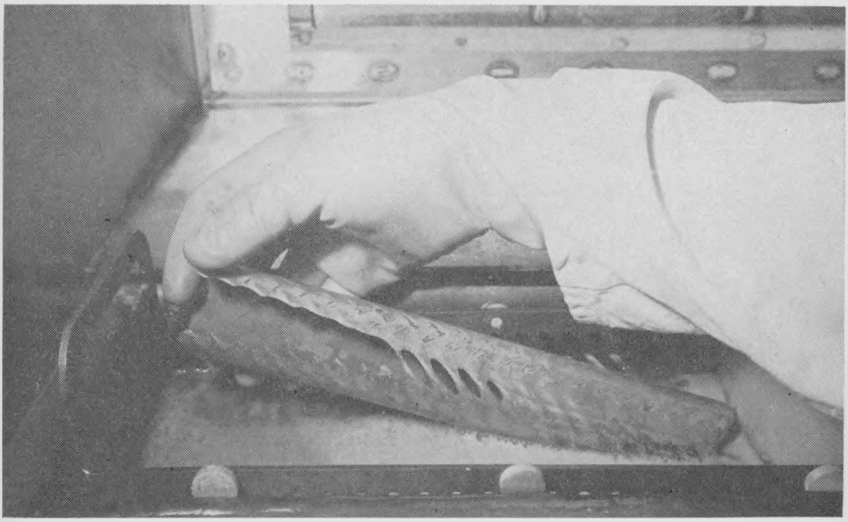
Fission Tracks from Californium-252 shown in the photomicrograph made at the Savannah River Laboratory illustrate a highly sensitive and specific tool for detecting and measuring fission events. Californium-252 atoms fission spontaneously, emitting energetic neutrons and fission fragments. The unique properties of this isotope make it an important source of neutrons for scientific and practical applications. To obtain the *above* photo, a sheet of clear mica was exposed to the fissioning isotope. The energetic fission fragments are stopped in the mica causing damage to the crystal structure. Their paths through the crystalline mica then are made visible by etching it with hydrofluoric acid, whereupon they appear as minute holes with the geometric shapes shown. Each fission event yields one track, while alpha and beta particles produce none. Scientists at Savannah River have used such fission track detectors to measure the rates of spontaneous fission of the rare isotopes curium-246 and -248 to a higher degree of accuracy than heretofore possible, as well as to measure the rate of neutron-induced fission in the production of californium from lighter elements by irradiation in reactors. The technique has also been found valuable in testing for the presence of spontaneously fissioning isotopes, particularly californium-252, when purifying other isotopes such as berkelium-249.

412-406—71——9

of total weight, f.o.b. National Reactor Testing Station, Idaho. This service is offered in the event that chemical processing of a spent fuel is not feasible from the economic viewpoint of the reactor operator. The AEC's policy for: (*a*) Receipt and financial settlement including provision for the cost of chemical processing or (*b*) disposal of spent research fuel is based on the condition that commercial services are not available at reasonable prices.

Electrolytic Dissolver

A unique new headend dissolver has been installed in the enriched uranium separations canyon building at the Savannah River plant. The dissolver uses electrolytic dissolution techniques to dissolve special fuels (stainless steel clad, stainless steel cermets, etc.) which could not be processed with conventional aqueous headend facilities The electrolytic dissolver will permit the recovery of hundreds of kilograms of uranium-235 from spent fuel which previously had been stored in fuel



A New Electrolytic Dissolver process developed at the National Reactor Testing Station in Idaho permits faster, more economical reprocessing of stainless-steel clad reactor fuels. Formerly, stainless steel fuels required slow, two-step batch dissolving, first in sulphuric acid and then in nitric acid. The photo *above* shows partially dissolved stainless steel, accomplished by applying an electric charge to the metal while it was immersed in nitric acid, an otherwise inert reagent for stainless steel. Plant scale equipment utilizing the new technique is being designed which will enable high capacity, continuous dissolution of stainless steel fuels at the Idaho Chemical Processing Plant at NRTS. The developmental research was conducted for the AEC by Idaho Nuclear Corp.

basins for several years because a dissolution capability was not available. A similar dissolver is currently being installed at the Idaho Chemical Processing Plant.

Plutonium Scrap Recovery

In an effort to reduce the current plutonium scrap backlog, both Savannah River and Hanford are processing nonproduction/nonweapon plutonium scrap generated in other AEC facilities. The highest priority is being given to the elimination of fire or safety hazards and in obtaining more accurate measurements for safeguard records.

A Hanford building, formerly used for plutonium concentration, is being modified to store and handle plutonium scrap; the modification will be completed in 1971. It will provide Hanford the capability to receive, for eventual processing, certain plutonium scrap which has been accumulating at other AEC sites that have no capability for processing this scrap. Plutonium recovery from AEC scrap has now been centralized in the Hanford operations as part of the AEC's effort to improve the management of plutonium scrap activities. At Hanford, primary emphasis is being placed on providing adequate scrap storage and handling facilities for reducing the current backlog of plutonium scrap at AEC sites and laboratories to normal operating levels. As a net result, this program will make better use of nuclear materials and improvements in safeguards and operations.

Curium-244 Separations

A separations campaign which recovered over 3,000 grams[12] of curium-244 was completed in the Savannah River Laboratory the last quarter of 1970. This campaign provided about 2.5 kilograms of the isotope curium-244 for heat source development work being conducted at Oak Ridge National Laboratory, and 700 grams were used for target material (by being irradiated in *Savannah River* plant high flux reactor charge) for the production of californium-252.

Uranium-233 Separations

The Savannah River and Hanford chemical separations facilities processed irradiated thorium fuels to recover uranium-233, a fission-

---

[12] A gram is about 1/28th of an ounce; a milligram is 1,000th of a gram; and a microgram is 1 millionth of a gram. There are about 454 grams in a pound.

able isotope. The uranium-233 was produced in the production reactors at each site by adding a neutron to natural thorium. The recovered uranium-233 (600 kilograms) is to be fabricated into a new fuel core for the Shippingport reactor in connection with the light water breeder reactor program.

Californium-252

The heavy element californium is produced at the Savannah River Plant by irradiation of plutonium-242, americium-243, and curium targets in high flux reactor charges. For earlier availability of californium-252 (Cf^{252}), some of these irradiated targets are being sent to Oak Ridge to separate the californium-252 isotope for use in the market evaluation program. The americium-curium residual is returned to Savannah River where it is made into targets for recycle to the reactors.

For large scale continuous separation of californium-252 and other radioisotopes, a multipurpose processing facility is being installed in an eixsting separations building at Savannah River. The facility, which should be ready for operation by early 1972, will permit separation of kilogram quantities of americium and curium and at least 15 grams of californium-252 per year as well as recovery of high-purity plutonium-238, berkelium, einsteinium, and fermium. Ultimately the facility can have a capacity of 100 grams of californium-252 per year.

Californium-252 is an intense neutron-emitting isotope which is being produced by the AEC for possible use in industry, education, medicine, and research. It has a relatively long half-life of 2.65 years, and low heat and gamma emission properties. One thousandth of a gram of Cf^{252} emits about 2½ billion neutrons per second. Since its portability depends only upon shielding requirements, Cf^{252} may be the ideal source of neutrons for use in onsite applications such as industrial plants, for terrestrial, marine, or lunar mineral exploration, and for cancer therapy.

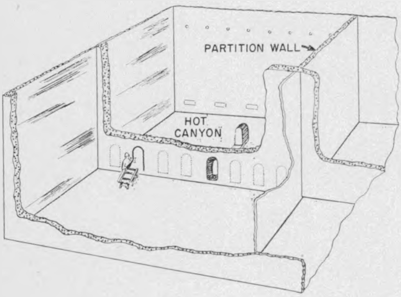
Market Evaluation Program

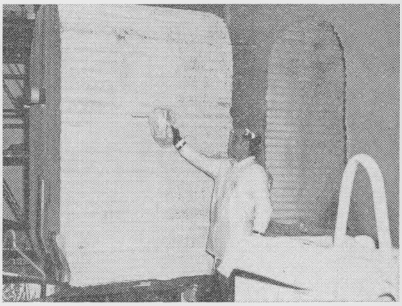
To determine the feasibility of certain uses of californium-252 and to predict future requirements, the AEC is loaning encapsulated Cf^{252} sources, free, to interested organizations. During 1970, 15 new loan agreements were signed bringing the total to 28 (see Table 3), the organizations performing studies with the sources and providing the

AEC with their reports. Progress in these investigations is summarized in the quarterly report: "California-252 Progress."[13]

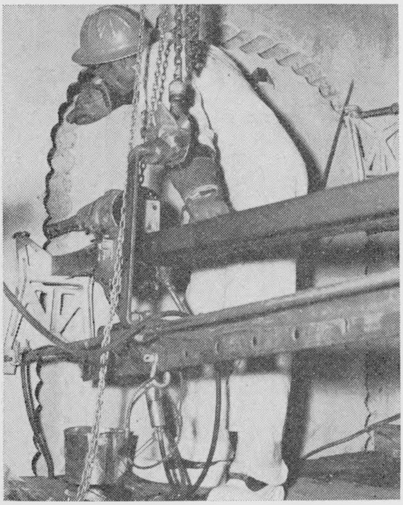
The results from these investigations have been encouraging. Californium has been shown to be effective in neutron radiography for industrial process control, measurement of sulfur in coal (a cause of air pollution), field oil well logging, and mineral exploration. One

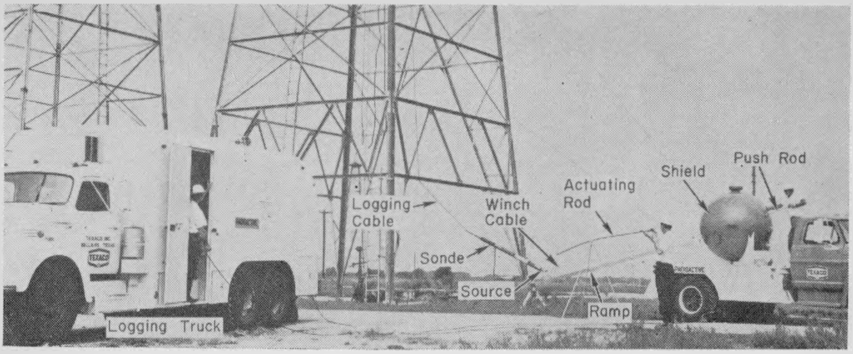
[13] Available without charge from Savannah River Operations Office, U.S. Atomic Energy Commission, P.O. Box A, Aiken, S.C. 29801.



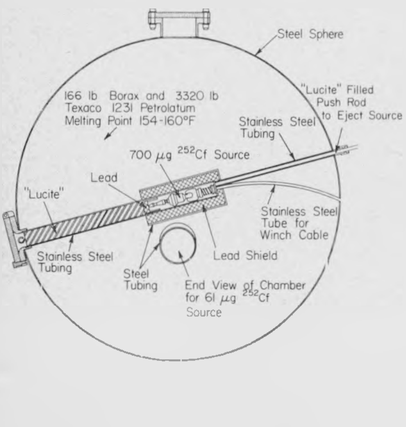


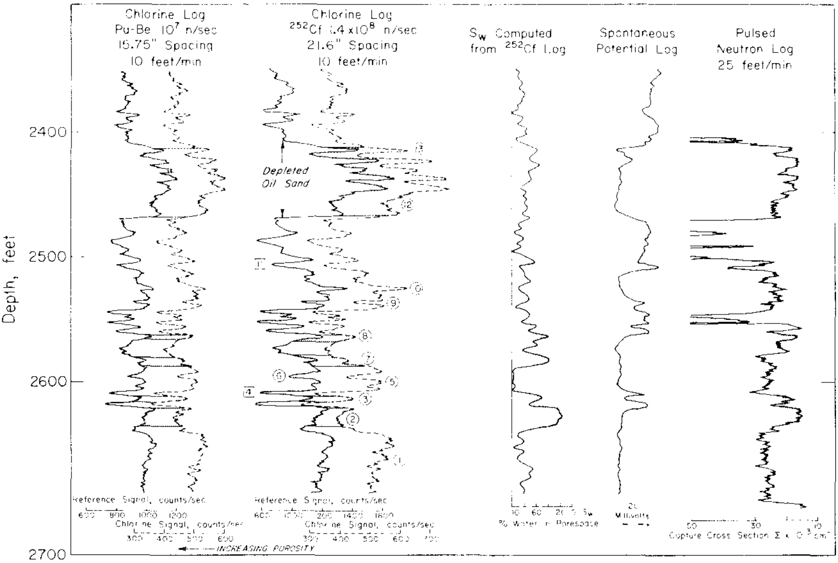
Cells for Remote Manipulation and direct viewing are being adapted from a portion of the hot canyon of one of the chemical separations plants at Savannah River to provide for separating and purifying californium-252 and other higher actinide elements. The canyon had been used for 15 years for large-scale separation of plutonium-239 from irradiated uranium. By installing a concrete partition wall between the selected portion of the canyon and that which is still in use for uranium separations, and by thorough cleaning of the interior surfaces of the walls and floors, it has been possible to reduce radiation levels so that protectively suited men can enter and work. Eight lead glass shielding windows and eight pairs of master-slave manipulators will be installed in openings cut through the 5½-foot-thick wall (see sketch at *upper left*). These openings were cut by core drilling 95 4-inch diameter holes around the periphery of each block to be moved as shown at *left.* Each block weighs 20 tons and is 9 feet high by 5 feet wide by 5½ feet thick. After being cut a block is pushed by hydraulic ram into the canyon space (*above right*) where a building crane transports it to a railroad car at the end of the canyon building for transfer to the burial ground. When completed, the multipurpose processing facility will handle californium in 100-milligram batches and separate other of the higher actinide elements that are produced in the Savannah River reactors.





Two Californium-252 Sources are being used under the AEC's "market evaluation program," by Texaco's Bellaire (Tex.) Research Laboratories to evaluate the usefulness of the manmade radioisotope for petroleum exploration. One of the sources contains 61 micrograms of californium-252 (Cf^{252}) the other 700 micrograms. Logging of six wells by Texaco has shown the Cf^{252} method to be extremely effective and faster than other methods. Because of the ease with which it can be handled, the 61-microgram source is considered the most useful since the difficulties in handling larger californium sources probably exceed the potential improvements in data that could be obtained. The truck-mounted shield for the californium-252 sources (shown *below left*) was designed so that the 700-microgram source could be remotely transferred from the shield to the logging sonde. The loading of the big source at a test well is shown *above* and involves five steps: (*a*) A special ramp holding the logging sonde is placed close to the port of the shield and the logging cable is attached to the sonde; (*b*) the du Pont-developed "Lucite" plug is removed from the shield and the ramp is aligned with the port; (*c*) the 700-microgram source (still attached to the winch cable) is pushed from the shield into the sonde with a 6-foot-long steel rod inserted through a small hole in the shield; (*d*) the sonde is automatically pulled by the logging cable until it is suspended above the well head to which a funnel has been attached; and (*e*) the winch cable is detached from the source with a 30-foot long actuating rod, and the sonde is lowered into the well. The sequence of the above operations is reversed to remove the sonde from the well and replace it in the shield. Each operation that requires an individual to be within 100 feet of the source takes less than 1 minute but results in a dose of about 0.5 mrem per man per operation. Although this is a low dosage and can be considered as an acceptable hazard, it is not considered feasible for routine operations. Thus, since the smaller (61-microgram) source does not give off such a radiation dose its practical usefulness is enhanced. Some results of Cf^{252} test are shown on the opposite page.





Chlorine Logging of Oil Wells with a 61-microgram californium-252 (Cf^{252}) neutron source has proven very effective in tests run by the Bellaire (Tex.) Research Laboratories of Texaco, Inc. A chlorine log (*second from left* in chart) of a well delineates low-salinity zones, which may contain oil. For the tests, the Texaco chlorine log, which measures gamma rays of selected energies from chlorine, is compared with a reference log, which is taken simultaneously by measuring gamma rays of a selected energy from hydrogen. The Cf^{252} chlorine logging system is superior to earlier chlorine logging systems that recorded extraneous responses from porosity and shaliness (boron content). When containing the 61-microgram source, the chlorine logging sonde uses a 4-inch-long by 2-inch-diameter sodium iodide detector with a source-to-detector spacing of 21.6 inches. Compared to plutonium-beryllium (Pu-Be) chlorine logs (at *left*) of the same formations, the Cf^{252} logs are insensitive to borehole salinity, give a maximum chlorine signal of 225 counts/second *vs.* 145 to 160 counts/second for plutonium-beryllium and are twice as sensitive to porosity. In the chlorine logs of a well, the convergence of the chlorine signal toward the reference signal indicates a zone containing less chlorine in the pores. At constant porosity, this convergence indicates the displacement of saltwater in the formation by oil. These logs indicate Zones 2, 3, 7, and 8 contain oil. Also shown (in *center*) are the water saturation (S_W) computed from the Cf^{252} chlorine log (S_W is the percent of water, fresh or salt, in the pores); a spontaneous potential log used to delineate the sand and shale formations of the well; and a commercial pulsed neutron log, which was run for comparison with the chlorine logs. The water saturation, S_W, is computed from the chlorine logs to help the geologist and reservoir engineer to determine potential oil-bearing zones. The pulsed neutron log (at *right*), which records the rate of decay of the thermal neutron population within the borehole, was made with a controlled 14-Mev. neutron generator—the only cased-hole log currently used by industry for distinguishing oil-bearing from saltwater-bearing formations. Because chlorine is the strongest thermal neutron absorbed in a borehole, this log can be compared with the californium-252 chlorine log by comparing S_W values. By substituting the 61-microgram Cf^{252} source for the Pu-Be source in Texaco's chlorine logging sonde and by changing the source-to-detector spacing to 21.6 inches, the logging speed can be increased from 10 to 30 feet per minute with the same signal-to-noise ratio.

of the most beneficial uses of Cf^{252} may be in cancer radiotherapy since initial results of studies have been encouraging.

As an extension of the market evaluation program, Cf^{252} medical sources, returned after use in the market evaluation program, are being loaned to universities for use in demonstration and laboratory courses under the AEC's extended loan program. Interest in this new loan program has been extensive; about 14 universities have obtained these sources and around 50 others have requested information on how to obtain them.

Sales Program

During 1970, large quantities of Cf^{252} became available from a Savannah River production reactor. In August, the AEC announced

TABLE 3.—ORGANIZATIONS CONDUCTING CALIFORNIUM-252 STUDIES

Organization	Use	Number of sources
American Science and Engineering, Cambridge, Mass	Process control	1
Argonne National Laboratory, Argonne, Ill	Neutron radiography	1
Battelle Memorial Institute of Columbus, Columbus, Ohio.*	Neutron radiography	1
Brookhaven National Laboratory, Upton, L.I., N.Y	Cancer therapy	160
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
Gulf Energy & Environmental Systems, Inc., San Diego, Calif.*	Safeguards of nuclear materials	4
Gulf Research & Development Co., Pittsburgh, Pa	Process control	1
Hospital of University of Pennsylvania, Philadelphia, Pa.	Cancer therapy	52
International Neutronics, Inc., Los Altos, Calif*	Process control	4
Kansas State University, Manhattan, Kans	Quality and process control	5
Kerr-McGee, Oklahoma City, Okla*	Uranium exploration	1
M.D. Anderson Hospital and Tumor Institute,Houston Tex.	Cancer therapy	76
National Bureau of Standards, Gaithersburg, Md	Neutron activation analysis	8
Picatinny Arsenal, Dover, N.J*	Neutron radiography	2
Republic Steel Corp., Cleveland, Ohio	In-process control	2
Schlumberger Technology Corp., Ridgefield, Conn	Petroleum exploration	3
Sloan-Kettering Institute, New York City*	Cancer therapy	32
Texaco, Inc., Bellaire, Tex	Petroleum exploration	2
U.S. Bureau of Mines (Dept. of Interior) Morgantown, W. Va.	Analysis of sulfur content of bituminous coal.	5
U.S. Dept. of Agriculture, Sedimentation Laboratory, Oxford, Miss.	Moisture and density measurement	1
U.S. Geological Survey (Dept. of Interior) Washington, D.C.	Mineral exploration and oceanography.	5
University of Cincinnati, Cincinnati, Ohio	Radiobiology	20
University of Georgia, Athens, Ga.*	Undersea mineral exploration	1
University of Hawaii, Honolulu, Hawaii*	Water well logging	1
University of Texas, Austin, Tex*	Neutron activation analysis, radiography forensics, and safeguards.	1

* New in 1970.

plans to offer for sale unencapsulated quantities of this material and, on November 1, a price of $10 per microgram for material available early in 1971 was established. Previously, only small research quantities (milligrams) of the californium-252 were available for purchase from AEC at a price of $100 per one-tenth of a microgram. The AEC is anticipating that industry will provide the necessary services for source fabrication and recovery of Cf^{252} from spent sources. Industry's response to initial sales of Cf^{252} will provide the AEC with information necessary to plan future production campaigns.

Heavy Water Production

During 1970, 198 tons of virgin heavy water were produced in the Savannah River heavy water plant. Deliveries to foreign purchasers, primarily for use in power reactors were the highest during any year to date, totaling 958 tons. These deliveries which were equivalent to about 5 years production at current levels of operation, were met by reducing the AEC's heavy water inventory. Additional commitments for foreign sales during the next 2 years will also require deliveries in excess of production during this period which will further reduce the AEC inventory. U.S. sales, primarily for research, and for the manufacture of deuterium gas and deuterated compounds, totaled six tons, a slight increase over 1969 sales. In addition to the above sales, about 12.5 tons of heavy water were transferred to AEC laboratories in support of research and development.

RADIOISOTOPE SALES

During the 11 months ending November 30, 1970, a total of 1,044,843 curies of processed radioisotopes were distributed by Oak Ridge National Laboratory, the principal sales point for radioisotopes distributed by the AEC. This represents a decrease of 55 percent compared to the same period in 1969.

Sales Price Reductions

During 1970, the AEC reduced its prices for plutonium-238, americium-241, and californium-252 (see previous "californium-252" item). The plutonium-238 and americium-241 actions were published in the *Federal Register* on May 27, 1970.

Plutonium-238. The AEC is making available about 1,000 grams of plutonium enriched to 90 percent plutonium-238. Most of the plutoium-238 is being produced at the Savannah River plant, with lesser amounts at Hanford, and will be available early in 1971 at $1.25 per milligram (one-thousandth of a gram) or $1,250 a gram. Plutonium-238 can be used commercially in heat and neutron sources and possibly to power heart pace-makers and heart pumps. In addition to being enriched to at least 90 percent plutonium-238, the plutonium will contain not more than 0.3 parts per million of plutonium-236. The 236 isotope decays through uranium-232 and highly energetic gamma-ray emitting radioisotopes. Both Hanford and Savannah River have demonstrated the ability to produce plutonium-238 with a low 236 isotope content.

The AEC is also reducing the price of plutonium enriched to between 80 and 89 percent plutonium-238. The new price will be 70 cents per milligram ($700 a gram). The previous price was $1,000 a gram.

Americium-241. The price of americium-241 is being reduced from $1,000 per gram to $150 a gram. Americium-241 can be used in nuclear gauges to measure the thickness of metal sheets, in location-sensing devices, and as a neutron source to log oil wells and measure the moisture content of soils.

The proposed price reduction is consistent with the AEC's policy of recovering full costs of the production and distribution of a radioisotope. The americium-241 is being produced at the AEC's Rocky Flats (Colo.) plant.

NUCLEAR MATERIALS SAFEGUARDS

The continuing growth of the nuclear industry adds increasing complexity to the nuclear materials accountability aspects to safeguard special nuclear materials from diversions to unauthorized uses.

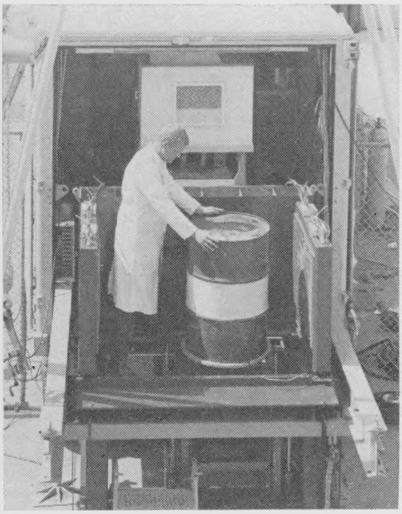
RESEARCH AND DEVELOPMENT

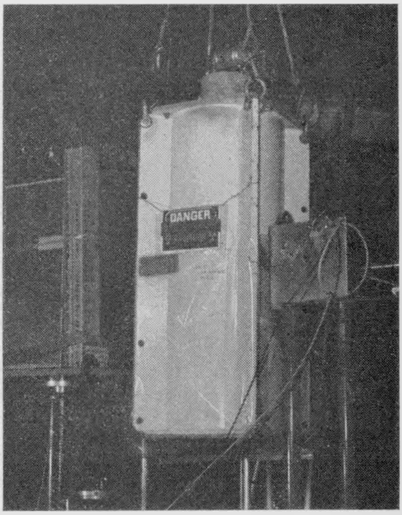
Research and development for nuclear materials safeguards has continued on nondestructive assay techniques. During 1970, delayed neutron assay methods were applied for the first time at Los Alamos Scientific Laboratory (LASL) to determine fissile material content in civilian reactor fuel elements; the uranium-235 content of a boiling water reactor mockup element was measured to within about 2 percent and the fissile content of a highly irradiated Materials Testing Reactor (MTR) fuel element was assayed at LASL through the wall of a massive lead shielding cask.

Mobile Laboratory Field Tests

The Mobile Nondestructive Assay Laboratory (MONAL),[14] developed by Los Alamos Scientific Laboratory was field tested for assaying plutonium scrap and for assaying enriched uranium. During May, June, and early July, the MONAL was at the AEC's Rocky Flats Plant near Golden, Colo., to evaluate several nondestructive assay methods for plutonium scrap and waste in 1-gallon and 55-gallon containers. Experience at Rocky Flats demonstrated that: (*a*) Non-

[14] See p. 64, "Annual Report to Congress for 1969."





Nondestructive Assay Methods for determining the fissionable content of materials was demonstrated both in the laboratory and in the field during the year. Two mobile laboratories were in use at nuclear plants at yearend—the Los Alamos Scientific Laboratory's MONAL (Mobile Nondestructive Assay Laboratory) system, and the GAMAS (Gulf Atomic Mobile Assay System). Photo at *left* shows a 55-gallon drum containing scrap materials being loaded into the GAMAS for a safeguards assay for fissionable material content. The system was developed by Gulf Radiation Technology (San Diego, Calif.) and is contained in a conventional instrumentation trailer. It includes a compact electron linear accelerator, radiation detectors, a computer, and barrel handling equipment. A beam of *bremsstrahlung* (high energy X-rays) capable of causing fission probes the interior of the barrel. Neutron detectors alongside the barrel record the fission neutron response and the computer uses the data to calculate fissionable internal content. Photo at *right* shows the experimental arrangement at the Los Alamos Scientific Laboratory for assay of "spent" research reactor fuel elements. The spent element is encased within the large (5,000 lb.) lead cask labeled "Danger, Radiation." The assay of the high burnup (35%) elements for residual enriched uranium showed an amount well within the 3 percent uncertainty in the reactor operators calculations.

destructive assay of up to 1-gallon size plutonium scrap and waste containers whose isotopic composition is known or independently measurable, can be performed routinely in the field with portable neutron coincidence detector systems to an accuracy of 1 to 5 percent; (*b*) up to 55-gallon size plutonium scrap in a nonmetallic matrix can be assayed routinely with the MONAL 8-unit sodium iodide (NaI) barrel scanner to an accuracy of 10 percent or better; (*c*) active neutron interrogation techniques can be used to assay up to 55-gallon size plutonium scrap in metallic matrices to an accuracy of 10 percent or better. Later in the year, the MONAL operated at the AEC's Fernald (Ohio) scrap processing facility for low enrichment uranium which is operated by National Lead of Ohio. It is scheduled for operation at private plants in the Pittsburgh, Pa., area in early 1971, and in the Oak Ridge, Tenn., area in mid-1971.

The Gulf Atomic Mobile Assay System (GAMAS),[15] which uses different techniques, was developed at San Diego, Calif., by Gulf Radiation Technology (a division of Gulf Energy and Environmental Systems, Inc.). Its initial shakedown tests were successfully carried out at Atomics International, Santa Susana, Calif., and, subsequently, GAMAS went into operation at the AEC's Rocky Flats (Colo.) Plant to field test measurement techniques for plutonium in waste and scrap. Along with passive equipment and a digital computer, GAMAS contains a linear electron accelerator—a versatile radiation source for safeguards purposes. It produces prompt and delayed fission neutrons in materials assayed using either *bremsstrahlung* or interrogating neutrons from beam targets.

Plant Safeguards Tests

Additional practical experience in applying nondestructive techniques to measurement of special nuclear materials in operating plants is being obtained under a plant instrumentation program and an integrated safeguards experiment. In the jointly supported AEC-industry instrumentation project a variety of active and passive assay systems have been installed and are being tested in AEC-licensed industrial plants which include plutonium fuel fabrication facilities and uranium feed materials preparation and scrap recovery facilities.

Private firms engaged in fabrication of plutonium fuel and processing enriched uranium are participating in joint 1- and 2-year efforts under which the techniques of measuring low-level radiation from nuclear fuel materials and inferring from the amount of radiation

[15] See pp. 117–118, "Fundamental Nuclear Energy Research—1968"; p. 65, "Annual Report to Congress for 1969."

emitted the amount of material being measured are being applied under actual operating conditions. Participants include Westinghouse Electric Corp.'s Nuclear Fuel Division, Cheswick, Pa; General Electric Co.'s Nuclear Energy Division, Pleasanton, Calif.; Atlantic-Richfield Co.'s NUMEC plant, Apollo, Pa.; United Nuclear Corp.'s scrap recovery plant (Wood River Junction, R.I.), and its chemical operations at Hematite, Mo.

The integrated safeguards experiment is in progress at General Electric's plutonium fuel fabrication facility. The objective of this experiment is to evaluate the usefulness to safeguards of the measured materials balance.

Safeguards Training School

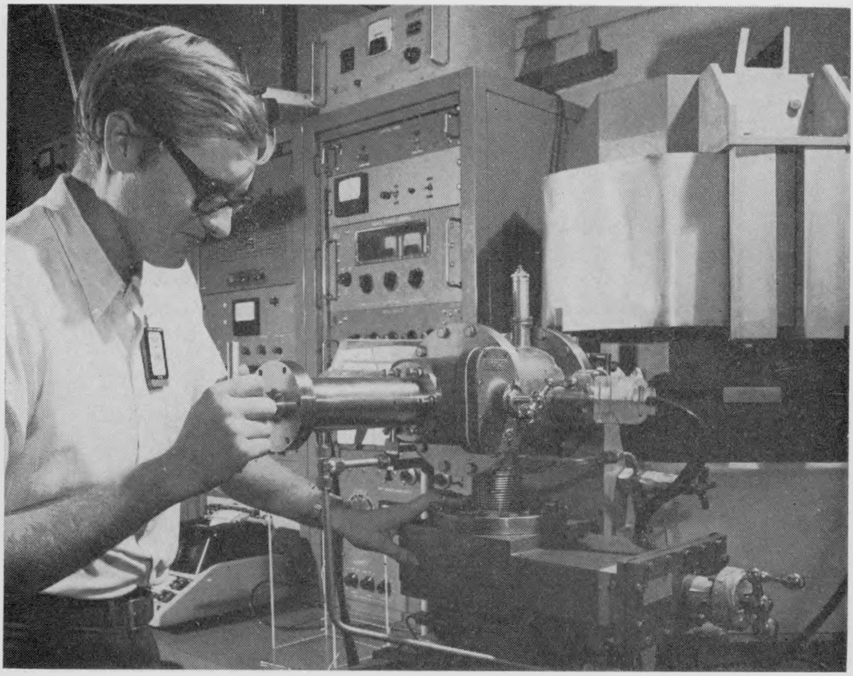
The AEC's Safeguards Training School at the Argonne National Laboratory continued to offer basic and specialized training for U.S. and foreign safeguards personnel, bringing to bear contributions from various disciplines and technologies. During 1970, the school accommodated 69 participants: 25 from U.S. Government organizations; 28 from domestic industry; and 16 from foreign organizations. The laboratory also devoted a 1-week session of an August faculty-student conference to safeguards. This effort is intended to encourage universities to incorporate safeguards-oriented subject matter into their curricula and thus provide trained manpower for this growing activity.

INTERNATIONAL SAFEGUARDS ACTIVITIES

The nuclear Nonproliferation Treaty (NPT) entered into force on March 5, 1970. Article III of the NPT requires each nonnuclear-weapon state that is a party to the treaty to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency (IAEA) for the exclusive purpose of verification of the fulfillment of its obligations assumed under the NPT. This is intended to prevent diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Representatives from the United States and 47 other IAEA member states met in two different sessions during 1970 as an IAEA committee to consider the character of the safeguards agreements to be concluded with nonnuclear-weapon states under the NPT, the detailed safeguards procedures to be included in the agreements, and methods for financing IAEA safeguards.

The AEC and its contractor personnel participated in two IAEA working groups and a symposium during 1970. The working groups considered specific safeguards questions such as facility design information required for safeguards and safeguards data collection and verification.

The number of countries in which U.S. bilateral safeguards are implemented is decreasing as the policy (see Chapter 10—International Affairs and Cooperation) for transfer of the safeguards responsibili-



An Analytical Laboratory Evaluation program has been initiated at the AEC-operated New Brunswick (N.J.) Laboratory. The program, which will involve work on plutonium as well as uranium, is designed to provide reference standards and to determine the routine analytical performance of licensee and contractor laboratories. The first phase of this program, involving the exchange of well characterized uranium dioxide (UO_2) samples, is now underway. Photo shows a sample being inserted into a mass spectrometer for isotopic analysis at the laboratory. The facilities at New Brunswick were expanded during 1970 by the addition of a hot-cell laboratory and a new plutonium assay laboratory to accommodate the increasing demand for safeguards analytical services. During 1970, the former New Brunswick Area Office was renamed New Brunswick Laboratory to better reflect its current activities of providing analytical development and support services for the AEC's safeguards and other programs, and developing and maintaining analytical measurement standards for nuclear materials programs. (See also footnote 4 in Appendix 1.)

ties to IAEA is carried out. However, in the six countries where bilateral agreements continue in effect, 40 facility inspections were carried out by U.S. inspectors.

The "Four Reactor Agreement" [16] which provided the IAEA an opportunity to develop certain safeguards techniques and which had served its intended purpose, expired on July 31, 1970. However, to continue U.S. cooperation with the agency in developing effective safeguards, arrangements have been made to enable the IAEA to take part in safeguards exercises at certain U.S. facilities which volunteer to cooperate. This is an interim step until such time as the Presidential offer [17] of December 2, 1967, to submit all U.S. peaceful nuclear activities to IAEA safeguards is implemented. The U.S. Government and the nuclear industry are currently preparing for that eventuality.

Additionally, the United States continued to provide strong assistance to the IAEA safeguards program through technical experts, the results of research and development, and safeguards training opportunities.

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 and/or plutonium in an unsealed form. At the end of 1970, there were 35 facilities operated by such licensees, including nuclear fuel processors, fabricators, and reprocessors. During the year, 58 safeguards inspections were conducted at 55 licensed power reactors and other licensed facilities.

Regulatory actions taken on behalf of the domestic safeguards program during 1970 included publication (see Appendix 4) in the *Federal Register* for public comment or adoption after publication.

- Amendments to 10 CFR Part 73, effective on January 30, which clarified responsibility for making arrangements for physical protection of special nuclear material while in transit.
- Part 73 of the AEC's regulations was expanded in scope by amendments which were published April 18 requiring that certain quantities and forms of special nuclear material must be provided physical protection while in use or storage.
- On May 16, amendments to 10 CFR Parts 70 and 150 were adopted requiring the use of new report forms to report transfers and infor-

[16] See p. 257, "Annual Report to Congress for 1965."
[17] See p. 216, "Annual Report to Congress for 1967."

mation about inventories, losses, and discards of special nuclear material. These forms will facilitate the collection, analysis, and use of safeguards data.

- Requirements for safeguards reporting were extended to source material licensees by amendment of 10 CFR Parts 40 and 150 on July 30, which require reports of transfers and inventories by persons authorized to possess 1,000 kilograms or more of source material. In addition, these licensees must report any attempt of theft, or unlawful diversion of source material.
- The AEC adopted, through amendments of 10 CFR Part 2 on May 16, a policy providing for the withholding from public disclosure of information concerning details of safeguards procedures and physical security measures in effect in a licensee's or applicant's facility.

Chapter 5

NATIONAL DEFENSE PROGRAMS

The AEC, in coordination with the Department of Defense, conducts two major programs directly related to the national defense and security effort—the nuclear weapons program, and the naval propulsion reactors program. Activities under both programs provided additional strength to the Nation's defense posture during 1970.

NUCLEAR WEAPONS

The Department of Defense (DOD) establishes nuclear weapons requirements in support of stated U.S. policies and the AEC, on the basis of these requirements, conducts the wide variety of basic and applied research and testing required for the development of new or improved nuclear weapons and devices. The AEC also produces the nuclear weapons which are deemed essential to the continued maintenance and the technical advancement of the United States nuclear defense capability.

The AEC, during 1970, continued: (*a*) The design, development, testing, and production of nuclear weapons and their components to meet DOD requirements approved by the President; (*b*) the development of nuclear devices, improvement of data acquisition systems, and advancement of test program diagnostic techniques; (*c*) maintenance of the safeguards associated with the limited nuclear test ban treaty; and (*d*) its cooperation with other countries or treaty organizations (*e.g.*, NATO) under mutual defense agreements for the exchange of authorized nuclear weapons information.[1]

[1] Twelve mutual defense agreements for cooperation are currently in effect (see Appendix 6—"Agreements for Cooperation").

412-406—71——10

WEAPONS PRODUCTION

The 1970 weapons production effort was directed primarily toward initial production of the warheads for the Minuteman III and Poseidon strategic missiles, while continuing the production of weapons for existing tactical and strategic systems.

Stockpile Improvement

In addition to new weapons production, the 1970 activities included improvement of stockpiled weapons through modification, quality assurance testing and evaluation of weapon reliability, and the production and delivery of training weapons and material. Retirement of obsolete weapons continued, with emphasis on maximum reuse of weapon components. The program has provided cost savings in production, maintenance, and training activities.

Production Facilities Expansion

The 5-year program of construction of production facilities and expansion and modernization of equipment required for new weapon systems will cost an estimated $315 million. Most of the facilities will be completed by 1972. Expanded facilities are being provided at the Y-12 Plant at Oak Ridge (Tenn.); Rocky Flats Plant (Colo.); Pinellas Plant (Fla.); Savannah River Plant (S.C.); Pantex Plant (Tex.); the Kansas City (Mo.) Bendix Plant; Mound Laboratory (Ohio); and the Burlington (Iowa) AEC Plant. Additional projects have been planned to enhance fire, safety, and operational adequacy throughout the production complex as a result of facts learned from the 1969 Rocky Flats Plant fire.

Rocky Flats Plant Fire

Restoration of the Rocky Flats Plant's production capability was accomplished during 1970. Two interconnected structures at the plant, located about 10 miles west of Denver, Colo., were damaged by a major fire on May 11, 1969, which severely reduced the plant's production capacity.[2] The plant is a major facility for plutonium parts fabrication for nuclear weapons. By May 8, 1970, just 52 weeks after the fire, all of the affected areas were decontaminated except an area

[2] See pp. 72, 73, and 74 of the "Annual Report to Congress for 1969."

of severe fire damage which is not planned for decontamination until 1972. A significant portion of the estimated $45 million cost of the fire involved the plutonium decontamination work.

WEAPONS RESEARCH AND DEVELOPMENT

Nuclear weapons research and development in 1970 included studies of new 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. The research and development activities are 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, Calif. Nuclear design activities are conducted at the Los Alamos and Livermore facilities and nonnuclear engineering and development activities are conducted at the Sandia Laboratories.

Laboratory research and development included work to enhance the simulation of weapons effects and environments within the laboratory. Improved laboratory simulators were used in the development of new weapons materials and components and to improve the quality and reliability of experiments conducted in underground tests.

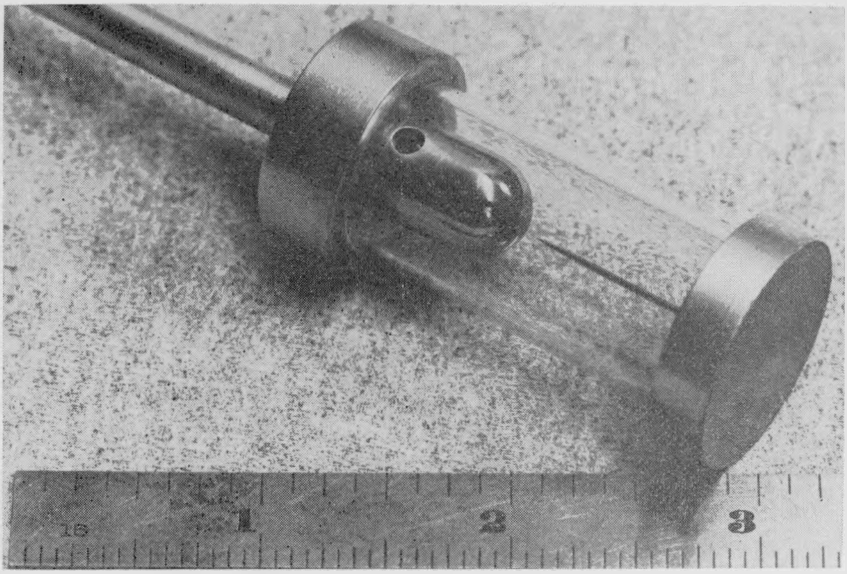
Underground testing, which directly supports the laboratory research and development programs, was concerned primarily with testing of weapons in development, with determining feasibility of designs for weapons use, with advanced nuclear device technology, and with decreasing warhead vulnerability. Improvements of diagnostic instrumentation systems continued. AEC technical and logistical support was provided for four nuclear tests required by the DOD.

UNDERGROUND NUCLEAR TESTS

The AEC continued its underground nuclear testing program at the Nevada Test Site (NTS) within the constraints of the limited nuclear test ban treaty.[3] The capability to support a wide variety of AEC and DOD nuclear tests has been maintained.

---

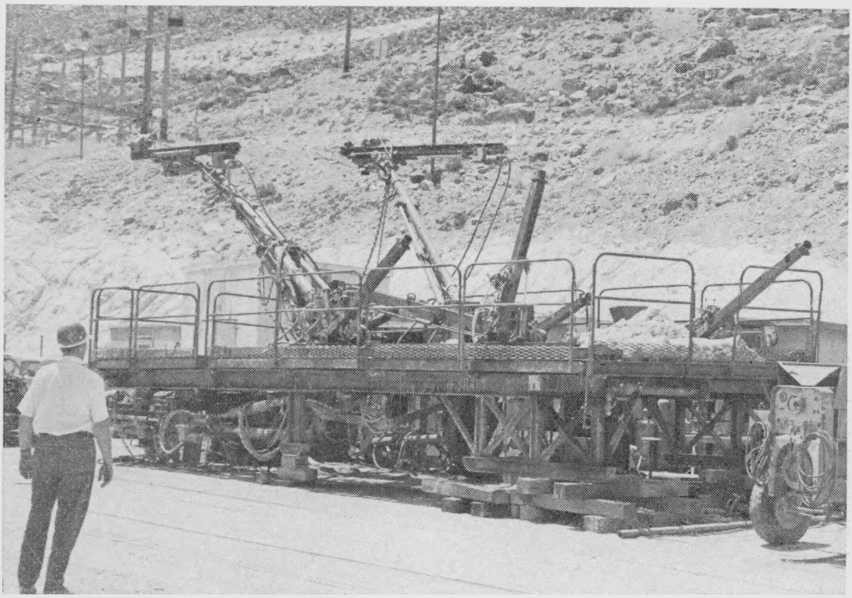
[3] Under the 1963 limited nuclear test ban treaty, nuclear detonations are prohibited in the atmosphere, outer space, and under water. Underground tests are permissible so long as they do not cause radioactive debris to be present outside the territorial limits of the nation conducting the detonation.



A Miniature Field Emission X-Ray Machine has been developed by E.G. & G.'s Las Vegas Radiation Laboratory to meet the needs of the AEC's weapons test research projects. The small, inexpensive, low-power, steady-state X-ray tube is only 2 inches long and 1-inch in diameter and could be packaged in a portable configuration about the size of a portable radio. It is inexpensive, costing only hundreds of dollars where the least expensive conventional X-ray machine would cost thousands of dollars. The miniature X-ray tube is capable of producing field intensities in excess of 1 *R*/hr. at 1 foot from the tube—the equivalent to many curies of a radioisotope. Construction of the tube is simple. The anode (*center* of photo) is a hemisphere of metal selected for the desired characteristic X-ray energy; the cathode (*right*) is an ordinary steel sewing needle. The cathode holder is machined from brass; the window is thin beryllium. These components are assembled with a vacuum compatible epoxy. The tube operates at 20 to 30 kv. and draws less than 50 microamps of current—no cooling is required. Power is provided by a small modular power supply which can operate from line voltage or batteries. In addition to its use in the weapons test programs, for which E.G. & G., Inc., is a prime contractor, possible applications include: (*a*) A small, portable, low-priced radiography unit for use in the field or in otherwise inaccessible places—the U.S. Department of Agriculture is considering its use for measurements of insect infestations in grain; (*b*) a low-priced research machine for use in studying characteristic radiations and *bremsstrahlung* from various materials; (*c*) a source of very-low energy radiation for use in making microradiographs; (*d*) a small, portable, low-priced X-ray machine for use in classroom demonstrations and school laboratories; and (*e*) a radiation source for X-ray fluorescence analyzers.

Mandrel-Emery Test Series

The 1970 nuclear tests consisted of parts of two test series conducted on a fiscal year (July 1–June 30) basis. The Mandrel test series ended on June 30, 1970. The Emery test series began on July 1, 1970, and will continue through June 30, 1971. The planned tests are grouped, by objectives, into three broad categories: (*a*) Defense-related (including device development and DOD nuclear effects tests); (*b*) joint AEC–DOD tests conducted for research and development purposes on the improvement of underground detection methods and systems; and (*c*) Plowshare (peaceful uses of nuclear explosives) experiments (see Chapter 9). All nuclear tests are reviewed by various panels to



The "Flying Carpet" is one of the latest mining and drilling innovations to come from the AEC's underground test program. The need for unique equipment to drill or mine shafts different from those normally done by industry has produced a number of new tools or methods that can easily be converted to commercial use. The "carpet" was designed and constructed by Reynolds Electrical & Engineering Co. and Fenix & Scission, Inc., two of the AEC's prime contractors at the Nevada Test Site. When in operation, it is mounted on rails on the sides of tunnels, moving deeper underground as mining operations progress. Capable of being used in underground cavities ranging from 18 to 40 feet in width, the "carpet" is designed for use in drilling and blasting, and for installing support for walls and ceilings while the steel bed protects workers in mucking operations below. This speeds up mining operations by permitting two phases of the work to be accomplished at the same time.

assure that they can be conducted in accordance with established AEC procedures concerning public safety and are consistent with U.S. obligations under the limited test ban treaty. In addition, the testing program is reviewed by the Council on Environmental Quality in compliance with the National Environmental Policy Act of 1969.

Test Summary

Twenty-three defense-related underground tests were publicly announced under the January–June 1970 portion of the Mandrel series, and six defense-related tests were publicly announced under the July–December 1970 portion of the Emery series (see Appendix 5). One of the 23 publicly announced Mandrel tests was a high-yield detonation conducted on Pahute Mesa of the Nevada Test Site; the Handley test on March 26, 1970, had a yield of more than 1 megaton. Ground motion was recorded by the seismic network at levels comparable to those experienced in the Benham test of 1968 [4] and in the Jorum test of 1969.[5] While the resultant ground motion from Handley resulted in damage claims, all such damage was minor in nature; that is, there was no structural damage.

Radiological monitoring in the offsite areas around the Nevada Test Site and other locations where nuclear explosions have been tested is conducted for the AEC by the Environmental Health Service (see "Operational Safety" section of Chapter 2).

Strike at the Nevada Test Site

A strike of construction crafts at the Nevada Test Site began on June 1, 1970, and was settled on September 22. The strike resulted in approximately 1,105,300 lost man-hours and there were no nuclear tests conducted between late June and mid-October.

Amchitka Test Area

Operations on the Amchitka Island, Alaska, supplemental test site are being conducted at a reduced level and are concerned with mining operations in preparation for the proposed Cannikin experiment scheduled for the fall of 1971. Additionally, effort is being devoted to the continuing seismic, ecological, hydrological, and geological surveillance associated with the Milrow test conducted in October 1969.

---

[4] See pp. 62–63, "Annual Report to Congress for 1968."
[5] See p. 75, "Annual Report to Congress for 1969."

The AEC's Weapons Test Program not only produces "spin off" equipment and techniques of commercial potential, but is also providing archaeological information on the history of mankind. Archaeological operations on Amchitka Island. Alaska, supplemental test site have salvaged six sites of archaeological interest from possible damage by AEC activities. The Amchitka sites consist of layers of loose, wet material, rich in artifacts. A new technique was developed to enhance artifact recovery. It involves washing all excavated soil materials through a fine screen using a high volume of water at low pressure as shown *above.* Artifact recovery was increased substantially through the use of water. Manmade tools and implements were encountered as deep as 9 feet below the surface. The study of the Amchitka material, including thousands of artifacts, has been reported in a 400-page document by Archaeological Research Inc., Costa Mesa, Calif., a nonprofit organization. The study shows that Amchitka was relatively heavily populated in prehistoric times indicating a good ecological area in spite of the cold, damp climate. Radiocarbon dating shows that one of the deeper man-occupied sites was inhabited about 500 B.C. Prehistoric man apparently transported himself to Amchitka—about 1,000 miles southwest of Anchorage and near the end of the Aleutian Islands chain—although no evidence has been found to identify the means of transportation. Most of his tools were made of native stone. The prehistoric Amchitka man's economy was entirely maritime. The archaeologists identified material from the excavations as bones of sea mammals (whales, seals, sea otters) and several varieties of sea birds. The shells of sea urchins, an edible shellfish, were found in great numbers as were the bones of many species of ocean fish. After contact of the Amchitkans with outside cultures, believed to have occurred in about 1753—some 10 years after Amchitka was "discovered" by Vitus Bering—disease and conflict began the decline of the Amchitka population. The last native Amchitkans were evacuated from the island at the beginning of World War II; except for temporary occupation by "outsiders," the island is now unpopulated.

The AEC, in 1970, participated in another transfer of sea otters from Amchitka to the Oregon and Washington coasts.[6] Since 1968, the AEC has participated in transferring nearly 600 otters from Amchitka to the Pribilof Islands, the coasts of Oregon, Washington, and British Columbia, and to other areas of Alaska. Surveys have indicated that the establishment of new colonies of otters, especially in Alaska, has been successful. An additional transfer of otters to Oregon is planned for the spring of 1971.

Central Nevada Test Area

The central Nevada test area, about 175 miles northwest of Las Vegas, has been placed in a caretaker status. A small support group has been stationed at the Tonopah (Nev.) airport office during the caretaker period. Usable equipment and materials have been shipped from the area to Amchitka and the Nevada Test Site.

ATMOSPHERIC TEST READINESS CAPABILITY

The AEC maintained an atmospheric test readiness capability during 1970, but at a somewhat reduced level.

Summary of Revised Readiness Capability

Among the 1970 actions taken by the AEC in revising the readiness capability were:

(*1*) The Johnston Island and the Hawaiian test facilities were placed in a standby status;

(*2*) Diagnostic aircraft operations and scientific missions continue at a reduced rate;

(*3*) Instrumentation development will proceed to the prototype stage.

(*4*) Contractor support has been reduced to maintain continuity with minimum personnel;

(*5*) The AEC Honolulu Area Office has been renamed the Pacific Area Support Office (PASO) and the assigned number of personnel reduced; and

(*6*) Joint AEC/DOD overseas readiness exercises have been discontinued.

---

[6] See pp. 75–76, "Annual Report to Congress for 1969."

Test Vehicle Developmental Launch

Portions of the Johnston Island complex and some facilities in Hawaii were reactivated for a short period in the fall of 1970 to launch a High Altitude Test Vehicle (HATV) developed by Sandia Laboratories. The launch, using a Thor missile, was made to determine: (*a*) If the design objectives had been met, and (*b*) that the Thor/HATV could place a nuclear device at a specific point in space at a specified time for testing. The successful operation simulated an actual high-altitude nuclear test and also provided an evaluation of improved tracking and optical instrumentation systems, both airborne and surface based.

Use of Diagnostic Aircraft

The three AEC-instrumented diagnostic aircraft (NC–135) continued to be used for scientific and technical missions in 1970. Such use helps to maintain the state of readiness of the flight crews and diagnostic equipment as well as provide new scientific information.

In January 1970, one of the aircraft conducted a combined cosmic ray and auroral airglow mission in the Hawaiian, Alaskan, and American Samoan regions and over distances in between. Another of the diagnostic aircraft participated in the large-scale scientific task group setup in the southeastern United States to observe the March 7, 1970, total eclipse of the sun. By flying along the path of totality (which would have been about 3 minutes locally) observation and recording of eclipse phenomena was extended to about 5 minutes and 30 seconds. Total eclipse measurements of the sun's corona, solar emissions, and other astrophysical data were recorded while flying above 30,000 feet.

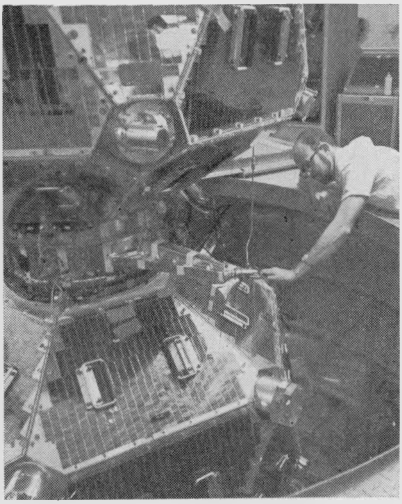
Two of the aircraft, in late May and early June, recorded data from rocket launches conducted by Sandia Laboratories from the Kauai Test Readiness Facility in Hawaii; and during the fall, the aircraft were again used on another scientific mission to investigate the conjugate [7] auroral, airglow, and cosmic ray phenomena in the Alaskan and New Zealand areas. All three diagnostic aircraft participated in the HATV launch from Johnston Island.

---

[7] Conjugate observations are taken in the northern and southern hemispheres at points where particular lines of force in the earth's magnetic field intersects the earth.

VELA PROGRAM ACTIVITIES

The AEC and DOD jointly conduct a research and development effort to improve the United States' capability to detect, locate, and identify nuclear explosions conducted in a variety of environments. The sixth, and final, launching of twin Vela satellites was made on April 8, 1970. The Advanced Research Projects Agency (ARPA) of the DOD supervises the overall Vela program.



The Last of the Vela Twin-Satellites, designated Vela V–B, were launched on April 8, 1970. The satellites, incorporating advanced instrumentation designed by the AEC's Los Almos Scientific Laboratory (LASL) are in near-circular orbits with radii of about 70,000 miles. The joint AEC–DOD satellite-based detection program started in October 1963 with subsequent launches in 1964, 1965, 1967, 1969, and the sixth, and final, launching of AEC-instrumented twin satellites into orbit in 1970. The Vela V–B launch was conducted by the DOD from Cape Kennedy and used a Titan III–C booster—the first three launches had used Atlas-Agena booster rockets. Photo at *left* shows the Vela V–B during final checkout at LASL. In addition to performing their function as "watchdogs" (the word Vela means "vigil" in Spanish) for possible clandestine nuclear testing in the atmosphere and in space, the Vela satellites—carrying neutron, gamma ray, and X-ray detection systems—have provided invaluable information to scientists on the nature of solar X-rays, the solar wind, and other natural phenomena. The Vela satellites are approximately 5 feet in diameter and consist of 12 instrumentation—or detector—points plus 24 solar panels. The panels provide the energy source of about 100 watts to power the Vela instruments and other spacecraft electrical systems. A number of other detectors and instruments, including a transmitter to transmit data to earth and a receiver to receive commands from earth, are contained inside the satellites. Each satellite weighs approximately 770 pounds. The latest launch was the sixth in the series but was designated V–B because it used the backup or spare equipment that was constructed originally for use in launch V (1969). Each progressive launch carried improved instrumentation as the state-of-the-art advanced and certain "bugs" were discovered in prior launches and eliminated. Approximately 20 types of instrument assemblies with more than 100 sensors have been designed, developed, tested and constructed by LASL groups for the satellites.

Vela Uniform

The recording of ground shock accelerations and other effects, both close-in and offsite, and the operation of short- and long-range seismic effects recording stations for Vela research and development data collection continued in 1970 in conjunction with the NTS underground test program.

Diamond Dust Experiment

The Diamond Dust detonation, the sixth Vela Uniform experiment [8] since 1963, was conducted on May 12, 1970, at the Nevada Test Site. The experiment, with a yield of less than 20 kt., was conducted in a tunnel complex and data were recorded on the degree of coupling of the energy of the nuclear explosion to the surrounding medium.

Operations at Tatum Salt Dome

The second [8] in a planned series of three DOD nonnuclear gas explosions in the Salmon-Sterling salt cavity near Hattisburg, Miss., was detonated on April 19, 1970. Seismic recording equipment accumulated useful scientific and technical data. The last of the three planned nonnuclear explosions was cancelled when it was determined that the desired data could be obtained from a test scheduled for the NTS in 1971. Analysis of data from the second detonation will be completed and then DOD activities at the Tatum Dome Site will end. The AEC is in the process of preparing the site for return to the owner which should be completed in the spring of 1971.

NUCLEAR FLEET

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

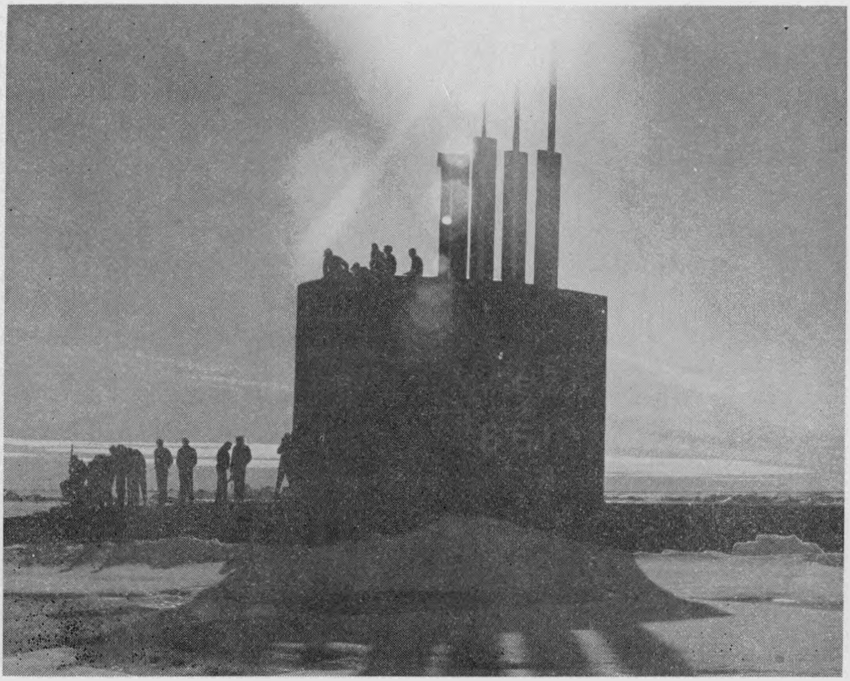
---

[8] See p. 79," Annual Report to Congress for 1969."

Operating Nuclear Ships

Congress has authorized 113 nuclear-powered submarines including 41 of the Polaris missile-launching type, one deep submergence research vehicle, and 10 nuclear-powered surface ships. Of these, 91 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 in operation and have steamed a cumulative distance of over 17.3 million miles.

During 1970 the aircraft carrier *Enterprise* was undergoing her second overhaul and refueling, having steamed over one-half million miles since commissioning in 1961, including four deployments off Vietnam; the *Long Beach* completed her third deployment to Southeast Asia and returned to the United States in the summer to begin



Men of the Nuclear-Powered Submarine USS *Queenfish* (SSN 651) and their ship are silhouetted against the midnight sun upon their arrival at the North Pole, August 5, 1970. This voyage, like previous historic nuclear submarine cruises, was made possible through the application of nuclear power to ship propulsion. Almost 12 years ago to the day, the USS *Nautilus* (SSN 571), the Nation's first nuclear ship, became the first submarine to transit under the Arctic ice. The present operation of the *Queenfish* will increase knowledge of the Arctic ice pack and its environment.

her second overhaul and refueling; the *Bainbridge* completed her fourth Far East deployment; and the *Truxtun* completed her second Vietnam combat deployment. These nuclear-powered surface ships continued to demonstrate, under actual combat conditions, the tactical flexibility and freedom of independent action that nuclear propulsion provides for surface warships.

The NR–1, the world's first nuclear-powered deep submergence research vehicle, demonstrated some specific capabilities applicable to both oceanographic and military missions. These included locating and recovering objects from the ocean floor, operating on or within 40 feet of the ocean bottom, and conducting continuous fine-grain bathymetric surveys without leaving the bottom-oriented reference system. The NR–1 went to sea for the first time in 1969.

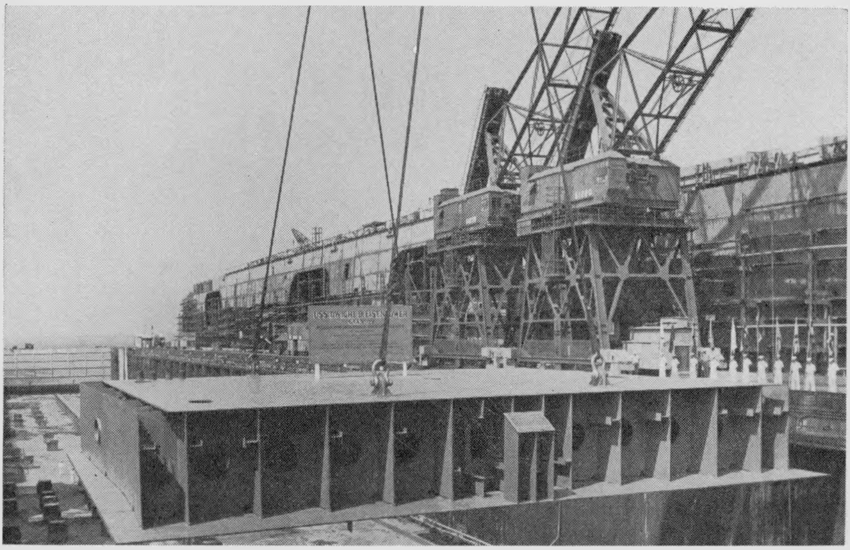
New Surface Ships Planned

During the year, construction proceeded on two guided-missile nuclear frigates, DLGN 36 and DLGN 37, at the Newport News Shipbuilding and Dry Dock Co. in Virginia. The keel laying of the *California* (DLGN 36) took place on January 23, 1970. The *California* is the first guided-missile ship of destroyer size or larger, conventional or nuclear-powered, since the frigate USS *Truxton* in the fiscal year 1962 shipbuilding program. The keel of the *South Carolina* (DLGN37) was laid on December 1. These 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 in 1968 by the President. These task groups will be a major step in the application of nuclear power to surface warships.

A high level of effort continued during 1970 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 at Newport News in June 1968. The keel laying, also at Newport News, of the second Nimitz-class carrier, the *Dwight D. Eisenhower* (CVAN 69), took place on August 15, 1970. The reactors for these carriers are the highest powered reactors under development in the naval program. Each produces about as much power as four of the *Enterprise* reactors. With these reactors, the ships will be able to operate for about 13 years without refueling.

New Submarines Planned

Work continued in 1970 on two new design nuclear attack submarines—the electric drive submarine, and the high-speed submarine.



The Keel of the Navy's Third Nuclear-Powered Aircraft Carrier, USS *Dwight D. Eisenhower*, is shown *above* as it was being laid at the Newport News (Va.) Shipyard on August 15, 1970. Construction of the USS *Nimitz*, the Navy's second nuclear-powered aircraft carrier, is visible in the adjacent dry dock. Distinguished guests attending the keel laying ceremony are shown *below*, from *left*, the Honorable Melvin R. Laird, Secretary of Defense, who was the keynote speaker; Mrs. Dwight D. Eisenhower II, President Nixon's daughter Julie; Vice Adm. H. G. Rickover, director, naval nuclear propulsion program; Mr. Dwight D. Eisenhower II, who authenticated the keel laying on behalf of President Nixon; Mrs. Dwight D. Eisenhower, the late former President's widow and now a resident of Gettysburg, Pa.; and Mr. L. C. Ackerman, president and chief executive officer, Newport News Shipbuilding & Dry Dock Co.

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 high-speed submarine, on the other hand, is being designed to be capable of higher operating speed than any other U.S. submarine developed to date. The fiscal 1970 shipbuilding program authorized construction of the first three of these new design highspeed submarines, and in July 1970, the President established the development and procurement of components for the first ship as a program of highest national priority. Four additional submarines of the new high-speed class are included into the fiscal year 1971 shipbuilding program and additional high-speed submarines are planned for the future.

The AEC continued throughout 1970 to emphasize research and development work on advanced naval reactor cores of greater reliability, higher power, and longer life. The first core in the USS *Nautilus* lasted about 2 years and propelled the Nation's first nuclear submarine for 62,000 miles; cores now being installed in nuclear submarines will last for more than 10 years of normal operation and will propel the vessels for approximately 400,000 miles.

Chapter 6

REACTOR DEVELOPMENT AND TECHNOLOGY

The AEC is concentrating its major effort in the civilian power reactor technology program on the development of safe, reliable, and economic liquid metal fast breeder [1] reactors (LMFBR) for the commercial generation of electric power.

BREEDER REACTOR DEVELOPMENT

The work on developing breeder reactors has the highest priority in the civilian power reactor development program because of: (*a*) The LMFBR's potential economic comparability with the light water reactors now in operation and being built in increasing numbers by utilities; (*b*) the ability of the LMFBR to more efficiently use the energy available in the Nation's nuclear resources; and (*c*) the compatibility [2] of the LMFBR fuel cycle with light water reactors. An additional advantage of fast breeder reactors is that their high temperature systems with higher thermal efficiency permit designs which will add less waste heat to the environment per unit of power produced than even the most modern fossil plants.

Work also continued, during the year, on the development of the light water, gas-cooled, and molten salt breeder reactors.

LMFBR TECHNOLOGY

During 1970, LMFBR technology development ranged from fuel and material development through the construction and use of experimental and test facilities, to planning the first demonstration plant to be supported by the Government.

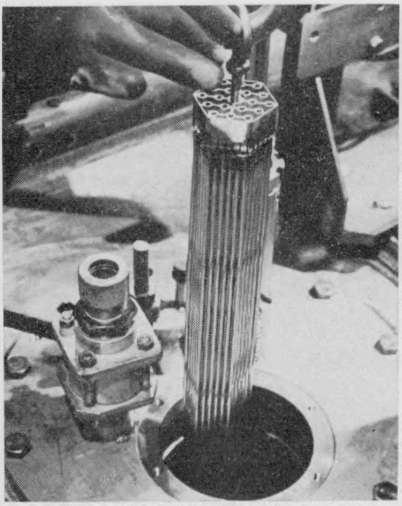
[1] During power operation, breeder reactors produce more fissionable material than they consume; fertile materials absorb neutrons which are in excess of those needed for maintaining the fissioning process, and this absorption converts the fertile material to material which is itself fissionable.

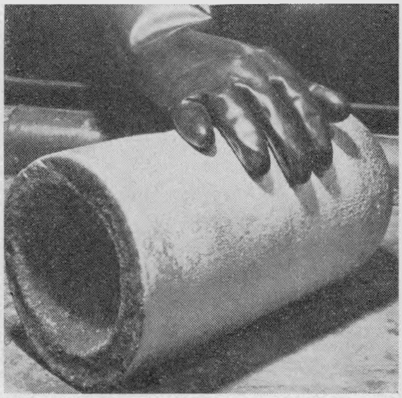
[2] Plutonium produced in light water reactors can be used to fuel fast breeder reactors.

Fuels and Materials

The objective of the fuel development program for liquid metal fast breeder reactors is to obtain a fuel capable of safe and reliable operation to 100,000 megawatt-days per ton of fuel (MWD/T) average and 150,000 MWD/T peak burnups.[3] Mixed oxide (plutonium and uranium) fuel is to be the fuel form for the Fast Flux Test Facility (FFTF) being built near Richland, Wash., and the prime candidate fuel for the first LMFBR demonstration plants. During 1970, mixed oxide fuel was irradiated in the Experimental Breeder Reactor No. 2 (EBR–2) in Idaho to a burnup of 115,000 MWD/T in a fast flux; and a burnup of 140,000 MWD/T was achieved in a thermal (slow neutron) reactor—the General Electric Testing Reactor (GETR)

[3] The amount of energy produced per unit weight of fuel fissioned.





Fuel Element Research and Development involves not only work on the fabrication and operational use of the fuel, but also how it can be reprocessed, after its use in a reactor, to recover the valuable and still-useful nuclear materials. Mixed plutonium and uranium oxides have shown a good potential as a fuel for the liquid metal fast breeder reactors of the future. Work at Argonne National Laboratory has shown that the stainless steel cladding used for the mixed oxide fuels can be separated from "spent" fuel elements relatively easily. In photo at *left*, a stainless steel-clad test reactor fuel assembly is lowered into a decladding furnace filled with molten zinc. The zinc dissolves the cladding but not the plutonium-uranium oxide fuel pellets which drop into a basket in the bottom of the furnace for recovery. This process is being developed at Argonne for use with high burnup fast reactor fuels. Photo at *right* is of a zinc-stainless steel ingot cast in the liquid metal fuel decladding process. The process should prove useful in decladding highly radioactive fast reactor fuels prior to reprocessing since the stainless steel is easily separated from the plutonium-uranium fuel material.

at Pleasanton, Calif. A total of 550 fuel pins in 11 different subassemblies are being irradiation tested in the EBR–2 to ensure that a statistical demonstration of burnup in excess of the 45,000 MWD/T average projected for the FFTF can be achieved within the next year.

Fuel Studies

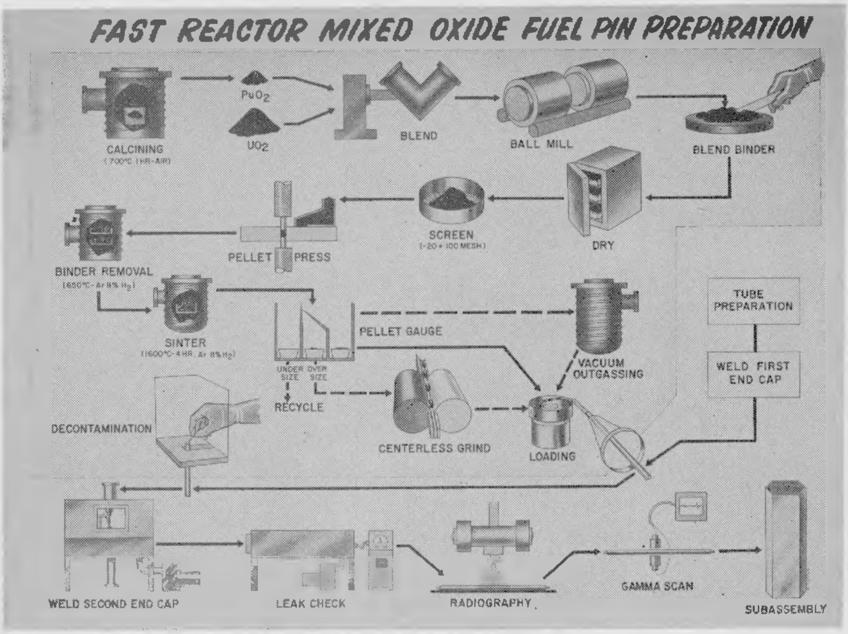
Fuel cladding with minimum swelling and interaction with the fuel is being sought. From post-irradiation examinations, it has been found that the fission products in mixed oxide fuel redistribute and penetrate the cladding grain boundaries in some cases. At high temperatures there can be a chemical reaction as well as mechanical interaction between the stainless steel cladding and the mixed oxide fuel pellets. These interactions are being investigated at Argonne National Laboratory, Hanford Engineering Development Laboratory, and General Electric to develop a base for reliable and economic operation of LMFBR fuel, particularly at elevated temperatures.

A major design problem, the swelling of stainless steel under fast neutron irradiation has been conclusively verified as being caused by the formation of voids in the steel by fast neutron bombardment. Sufficient data have been obtained to develop engineering designs which will accommodate the swelling. In addition, results indicate that thermo-mechanical treatments as well as changes in composition reduce swelling and increase high temperature strength.

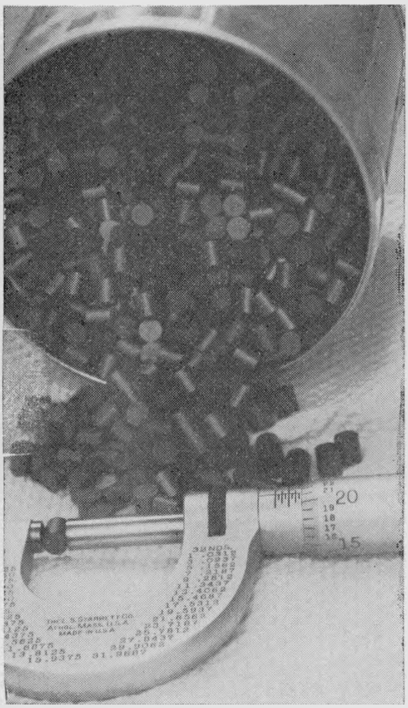
Plutonium Recycle

The major objectives of AEC's plutonium recycle program have been to demonstrate the technical and economic feasibility of using plutonium under operational conditions typical of reactors now operating or being put into operation, and to establish industry confidence in other vital areas related to recycling plutonium in large power reactors. The program is now in its final stages. All fuel and physics experiments, evaluation of calculational methods, specification of remaining areas of uncertainties, and documentation and dissemination of reports and computer codes are being completed. The one exception to this is the fuel demonstration in the Saxton (Pa.) Nuclear Experimental Reactor Project which has already demonstrated the adequacy of mixed oxide fuel to moderately high burnups (38,000 MWD/T peak) and will be continued to even higher burnups (50,000 MWD/T).

As the AEC's funding has been reduced, industry's efforts peaked during 1970 with mixed oxide fuel demonstration under typical light



Fuel Pins for the Fast Flux Test Facility (FFTF) will be composed of mixed oxides of plutonium and uranium. Drawing *above* provides a step-by-step description of the fuel pin preparation process developed at the AEC's Pacific Northwest Laboratory (PNL) and now being carried on at the Hanford Engineering and Development Laboratory. The mixed oxides fuel will be in the form of pellets (shown at *left*) about the size of an eraser on a lead pencil. About 3 million such pellets will be needed for operation of the FFTF which, when it goes into operation in 1973, will be the focal point for the liquid metal fast breeder reactor (LMFBR) development program. On July 1, 1970, at the request of Battelle Memorial Institute which operates the Pacific Northwest Laboratory for the AEC through its Battelle-Northwest Division, management responsibility for the FFTF and the associated LMFBR developmental work was transferred to Westinghouse Electric Corp. To differentiate the work now being done by Westinghouse through its WADCO subsidiary, the parts of the PNL where reactor work is being done were redesignated the Hanford Engineering Development Laboratory; Battelle still conducts studies at PNL for other, nonreactor programs of the AEC.



water reactor conditions underway in the power reactors at: Big Rock Point (Mich.), San Onofre (Calif.), and Dresden I (Ill.). Mixed oxide fuel will also be included in the first core loading of the Vermont Yankee reactor for demonstration purposes.

Program findings indicate that plutonium recycle in light water reactors should be technically and economically feasible during the period when significant quantities of plutonium are being produced (1974) and later, when the fast breeder reactors are in use by utilities.

Reactor Physics

The objective of the LMFBR physics program is to develop, verify, and disseminate the physics data and methods required for the design and operation of fast breeder reactors. The data are obtained by the use of complex machines such as the fast neutron generator (FNG) at Argonne National Laboratory (ANL), the Oak Ridge Electron Linear Accelerator (ORELA) at the Oak Ridge National Laboratory, and ANL's Zero Power Reactors (ZPR) in Illinois and the National Reactor Testing Station (NRTS) in Idaho. In addition, the AEC is participating in the work being performed at the Southwest Experimental Fast Oxide Reactor (SEFOR) near Fayetteville, Ark.

Neutron Cross Section Measurements

The fast neutron generator at Argonne became operational in May 1970. It is an advanced high intensity neutron source that will be used primarily for neutron cross section [4] measurements at energies above 1 Mev. (million electron volts). The initial measurements using the FNG provide accurate activation cross sections of several detector materials for use in monitoring radiation damage experiments, cross sections for gas production (hydrogen and helium) for radiation damage studies in structural materials and for detailed scattering, fission, capture, and total cross sections required for accurate fast breeder neutronic calculations. The FNG is also to be used as a neutron source for the time-of-flight [5] experiments to be performed on the ZPR-6 at Argonne.

The 140-Mev. ORELA is the most powerful machine in the world for measuring neutron cross sections in the lower end of the neutron energy range characteristic of fast breeder reactors. The ORELA is

[4] Effective area of a nucleus for interacting with a neutron, and thus a measure of probability that a nuclear reaction will occur.

[5] Time-of-flight is a technique used for measuring the distribution of neutron energies (spectrum) found in a critical assembly.

providing high resolutions data on simultaneous fission, capture, scattering, and total cross sections, primarily in the energy range less than 300 kev. (thousand electron volts) for the fissionable and fertile isotopes to be used in fast breeder reactors. Extensive measurements on plutonium-239 and -241, and uranium-235 and -238 are in progress. The results of these measurements will be used to substantially improve the nuclear data to be used in reactor, design calculations over the next few years.

Reactor Core Mockups

Plutonium fueled experiments in support of LMFBR core design have been initiated in the Zero Power Plutonium Reactor (ZPPR) at NRTS. These experiments on intermediate size (300 to 500 Mwe.) reactor core mockups represent initial plutonium-fueled "benchmark" critical experiments and are essential for the design of fast breeder reactors.

A series of experiments using a mockup of the core of the EBR–2 was conducted in the ZPR–3 at NRTS to assist in the fast breeder reactor fuel irradiation program being carried out in that reactor. ZPR–3, the oldest and smallest of the ZPR's, was shut down at the end of 1970 and placed in standby. Work of the type previously done with the ZPR–3 has been shifted to the other larger ZPR's.

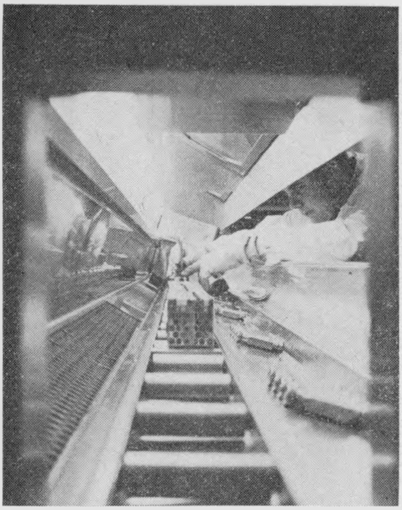
The ZPR–6 and ZPR–9 at ANL were modified to handle plutonium cores. ZPR–6 is being used for experiments using a reference assembly for the LMFBR demonstration plant program. General design critical experiments for the Fast Flux Test Facility (FFTF), previously done on ZPR–3 and later the ZPPR, were transferred to the ZPR–9 and a series of experiments are in progress to assist in the core design of the FFTF. These experiments will be followed by engineering-mockup critical studies for the FFTF.

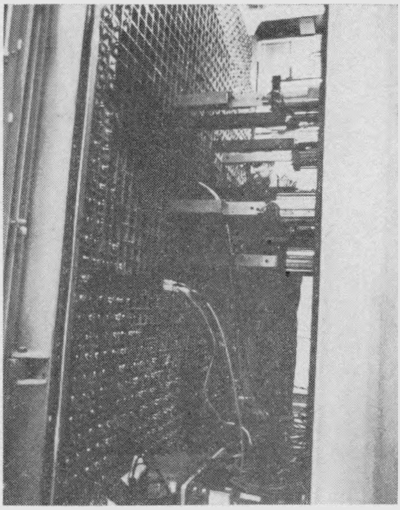
SEFOR Operational Experiments

Experiments at SEFOR are being conducted to demonstrate the operational safety of the LMFBR's. SEFOR is a privately owned, 20-Mwt. (megawatt thermal) sodium-cooled fast reactor [6] with characteristics similar to the large, soft spectrum fast breeder reactors fueled with mixed plutonium and uranium oxides (PuO_2-UO_2), for which studies indicate the potential for producing low-cost power. SEFOR is being used to obtain physics and engineering data charac-

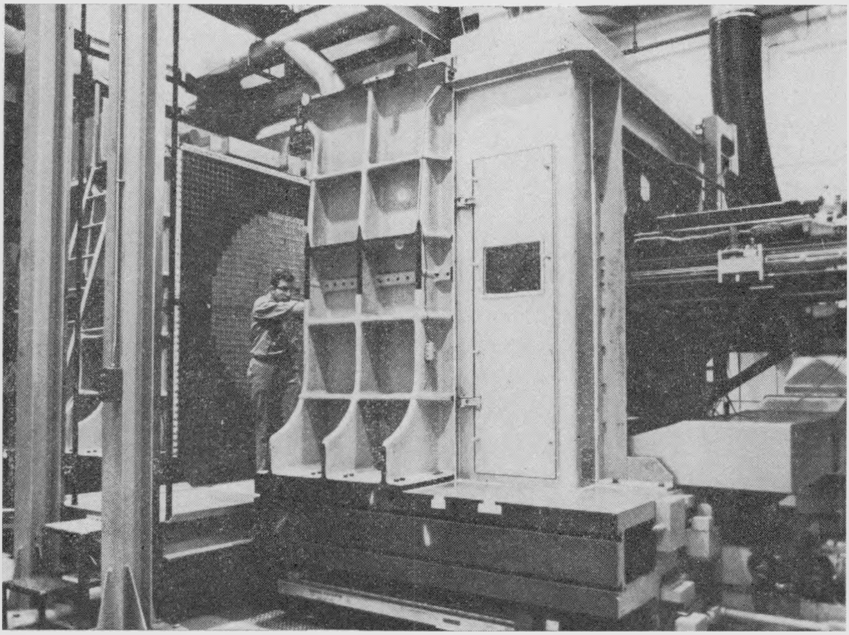
---

[6] See p. 93, "Annual Report to Congress for 1969."





Important Physics Characteristics of fuel configurations are being determined through studies using low-power, room temperature, critical experiments called zero power reactors (ZPR's). The ZPR–6 and ZPR–9 at Argonne National Laboratory have been modified to handle plutonium cores. The ZPR–6 is being used for "benchmark" critical experiments supporting the planned liquid metal fast breeder reactor demonstration plant; photo *above left* shows control rod assemblies being inspected. Photo *above right* shows plutonium fuel being loaded into drawers for insertion in the ZPR–6. The plutonium is handled within specially designed hoods to minimize the hazard of contamination. The ZPR–9, shown *below* is being used for a series of core design experiments for the Fast Flux Test Facility now under construction near Richland, Wash.



teristic of power reactor operating conditions. Operation has proceeded to the 17.5 Mw. power level. Analyses of data taken to date have shown generally satisfactory agreement with predicted design values for the reactor's operation. The reactor became operational in May 1969.

Component and Plant Development

The objective of the component and plant development program is to develop overall liquid metal breeder reactor design technology, instrumentation, and equipment. One of the most important testing facilities for the liquid metal systems is the Liquid Metal Engineering Center (LMEC) at Santa Susana, Calif. At the LMEC, the major operational test facilities are the Sodium Component Test Installation (SCTI) and the Large Component Test Loop (LCTL).

The primary function of the SCTI is to test LMFBR heat removal systems, heat exchangers, and steam generators. Liquid sodium, which is needed to remove large amounts of heat from relatively small reactor volumes, poses unique problems in terms of chemical activity and thermal shock potential.

During 1970, an American Locomotive Co./Baldwin-Lima Hamilton (ALCO/BLH) steam generator was tested in the SCTI. When the steam generator was removed for further metallurgical examination, the SCTI was prepared for tests on a modular-type steam generator being developed by Atomics International (AI). Design work and procurement of materials to install the AI unit in the SCTI are underway.

The LCTL was operated during the year with mock-ups of the Fast Flux Test Facility (FFTF) flow duct/receptacle area. Long-term tests were conducted to observe the erosion effects of liquid sodium at FFTF inlet core conditions of temperature and pressure. Also, under test at LMEC was a control rod drive mechanism of the same type as used on the nuclear ship *Savannah*. The control rod drive mechanism was being evaluated for use in a liquid sodium environment. The LMEC also was used in the acquisition of prototype FFTF liquid metal system components, such as intermediate heat exchangers, pumps, and valves.

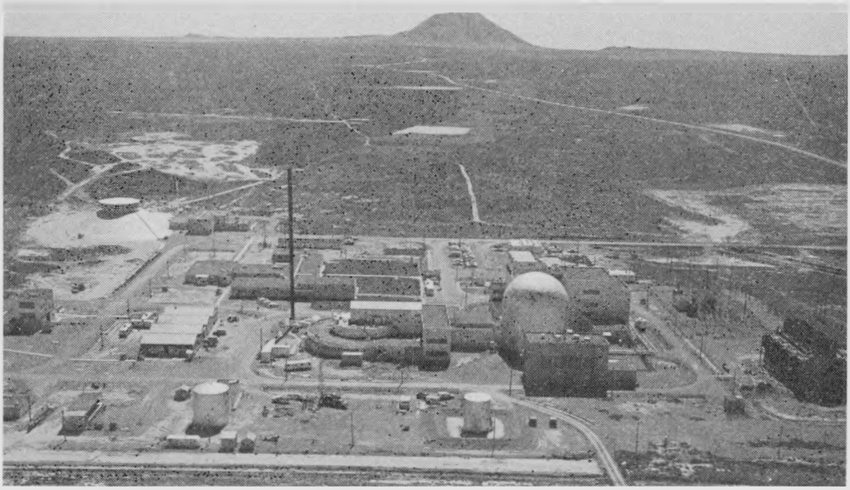
The detailed design of the Sodium Pump Test Facility (SPTF) is underway. The facility will permit testing of large (15,000 to 60,000 gallons per minute) pumps in sodium at temperatures up to 1,100° F.

The Liquid Metal Engineering Center also was taking part in the acquisition of prototype liquid metal system components, such as intermediate heat exchangers, pumps, and valves.

EBR–2 and FFTF

The two fast flux irradiation test facilities most essential to the successful development of LMFBR's are the Experimental Breeder Reactor No. 2 (EBR–2) in operation at the National Reactor Testing Station in Idaho, and the Fast Flux Test Facility (FFTF), under construction at the AEC's Hanford Works near Richland, Wash.

EBR–2. An instrumented subassembly containing LMFBR fuel experiments was successfully operated in the EBR–2 during 1970. The EBR–2 was originally designed as an experimental breeder engineering demonstration plant. However, in 1965, its primary mission was changed to that of an irradiation test facility for LMFBR fuels and materials; this required upgrading the reactor for: (*a*) Extended power operations and flexible irradiation testing capability, as well as (*b*) expanding the EBR–2 site facilities for increased examinations of irradiated fuels and materials. For extended power operation, the reactor was modified to raise its power level from 50 Mwt. to 62.5



The Experimental Breeder Reactor–2 (EBR–2) located at the National Reactor Testing Station in Idaho, is being used as a primary irradiation test facility for fuels and materials used in the liquid metal fast breeder reactor (LMFBR) program pending the planned 1973 completion of the Fast Flux Test Facility in Washington. The remoteness of the EBR–2 site is exemplified in the *above* aerial photo; the Zero Power Plutonium Reactor (ZPPR), which is also used for fuel experiments supporting the LMFBR program, is beneath the circular roof in the *upper left.* Originally intended as an experimental breeder power engineering and closed fuel cycle demonstration plant, the EBR–2 has been modified to provide a flexible irradiation capability at extended power levels.

Mwt.; EBR–2 was available in 1970 to carry out higher performance irradiation test operations and achieved a plant factor[7] of about 58 percent. Routine 62.5 Mwt. operation was started in September 1970.

As a part of the EBR–2 site expansion to meet LMFBR fuel examination needs, a Hot Fuel Examination Facility (HFEF) is being built. Examinations of fuels and materials currently being irradiated in the EBR–2 as well as in the Transient Reactor Test Facility (TREAT), Engineering Test Reactor (ETR), and the Power Burst Facility (PBF)—all at the Idaho site—will be performed in the HFEF. By the end of 1970, construction of the HFEF was about 40 percent complete and the facility is scheduled to begin operations in 1972.

FFTF. Successful LMFBR development needs not only the fast fluxes and test capability of the EBR–2, but the higher fast fluxes (more than double that of any test reactor in the United States) and greater test capabilities—particularly testing in closed loops[8]—which will be provided by the 400-Mwt. Fast Flux Test Facility (FFTF).

The AEC transferred management responsibility for all Fast Flux Test Facility and liquid metal fast breeder reactor programs and part of the remaining reactor development programs being conducted at the Pacific Northwest Laboratory to Westinghouse Electric Corp. on July 1, 1970 (see footnote in App. 3, p. 292). Westinghouse (through its Advanced Reactor Division, Pittsburgh, Pa.) previously had only the design responsibility for the plant. Westinghouse established a subsidiary, named WADCO, to perform the breeder reactor-associated work. The Fast Flux Test Facility is the key project for most of the presently planned technical work in the LMFBR program. The Bechtel Corp. (San Francisco, Calif.) has been serving as architect-engineer for general plant design; Atomics International (Canoga Park, Calif.) has been the principal subcontractor to Westinghouse.

At yearend, conceptual design of the facility is essentially complete, and major preliminary design activities have been initiated; conceptual design of the reactor vessel is also essentially complete and procurement of long lead-time items has begun. Construction of the FFTF building, by the Chicago Bridge and Iron Co., has been started.

---

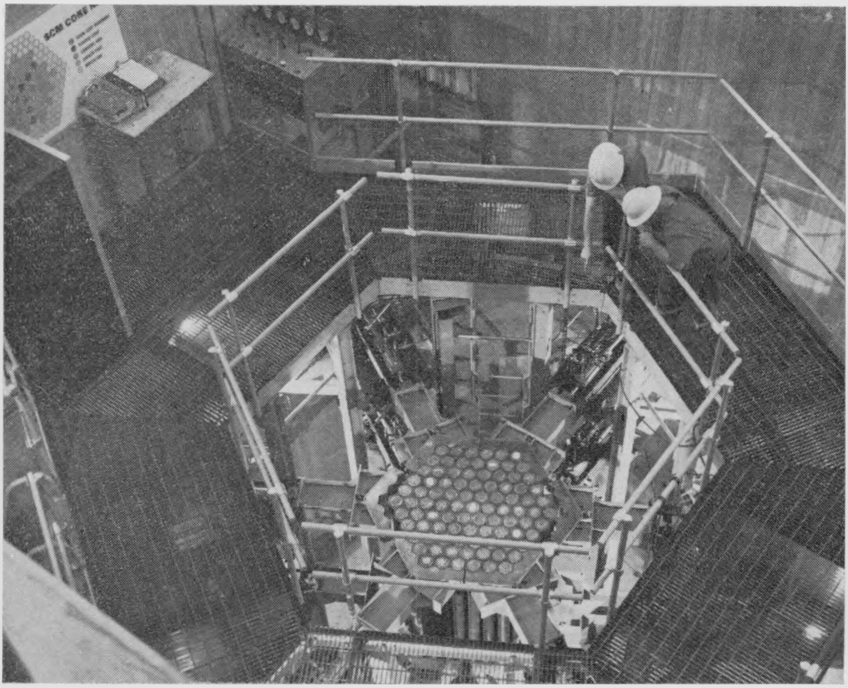
[7] Actual energy (thermal) generated divided by the total possible rated-power energy generation during a given period.

[8] A closed circuit of large pipe passing through the reactor into which specimens are placed to be tested under irradiation; the medium in which the specimen will be operating can be circulated through the pipe, providing an operating environment during test.

LMFBR Demonstration Plant

The AEC's development efforts for the LMFBR's will culminate in the actual demonstration of the technology in LMFBR plants operating on utility systems. In partnership with industry, the AEC has initiated a two-phase approach leading to the construction of the first LMFBR demonstration plant. The plant will be in the 300- to 500-Mwe. (megawatts of electricity) size range, and will be owned and operated by utilities.

The first, or project definition, phase was started late in 1969 with three contractors named to conduct the first-phase effort. The work's objectives include proposed plant and site definition; estimate of project cost; technical and economic risk assessment, and the scoping and



The Fast Flux Test Facility (FFTF), now under construction at the AEC's Hanford Works in Washington, will be the key project for most of the technical work presently planned in the liquid metal fast breeder reactor (LMFBR) development program. Conceptual design work on the FFTF was essentially complete at the end of 1970, and mockup facilities were being used to check out the designs. In photo, WADCO engineers discuss operation of the simulated core mockup for the FFTF. At present, only the core restraining mechanism is in place with the instrument tree to be added at a later date. WADCO, a wholly owned subsidiary of the Westinghouse Electric Corp., assumed the management responsibility on July 1, 1970, for the FFTF and the Hanford Engineering and Development Laboratory for the AEC.

planning of research and development; quality assurance programs and codes and standards efforts; engineering, procurement, construction, training, and operational effects; and the organizational contribution and operating relationships to be established between the architect-engineer, reactor manufacturer, utility, and the AEC.

AEC participation in the cost of the project definition phase effort is $4 million. Atomics International, General Electric, and Westinghouse are the three project definition phase contractors, each providing about $1.35 million in private funding, and each working with an association of electric utilities. They are attempting to define and organize the technical, management, and financial involvement believed necessary to successfully bring into being a safe and reliably operable LMFBR demonstration plant.

The second phase involved in the demonstration plant will be a definitive contractual arrangement for the design, supporting development, tests, construction, and operation of a specific plant. One of the three reactor manufacturers and the association of utilities performing first-phase work is to be selected to conduct the second phase in cooperation with the AEC. The second phase is to be started in 1971, with initial operation of the demonstration plant to begin in the late 1970's.

OTHER BREEDER REACTORS

In addition to the program to develop LMFBR's, work continued on the light water, gas-cooled, and molten salt breeder reactor concepts.

Light Water Breeder

During 1970, 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.

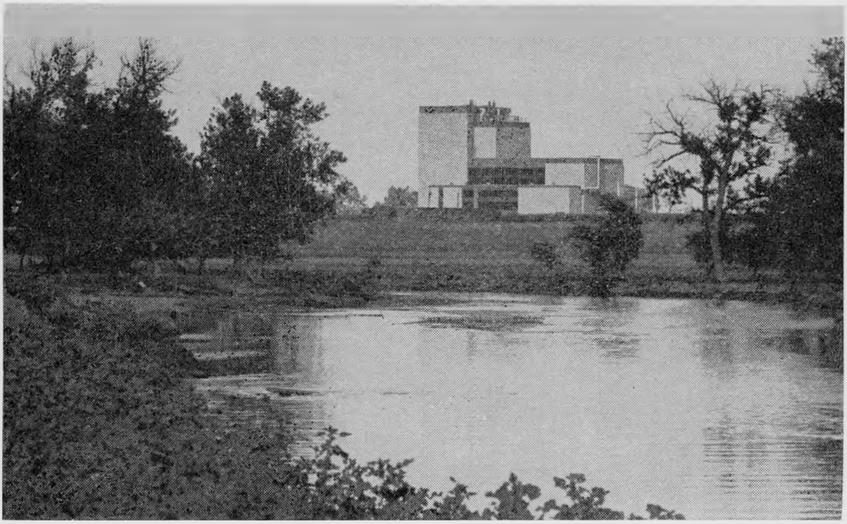
The light water breeder reactor, which uses the seed-blanket reactor concept along with the thorium-uranium-233 fuel cycle, is the only known approach for increasing the fuel utilization of light water thermal reactors significantly beyond the 1 to 2 percent achievable with present types of light water reactors. Successful demonstration of breeding in a light water reactor will provide the basic technology which could make available for power production about 50 percent of the energy in United States thorium reserves, a source of energy many times greater than known fossil fuel reserves. Successful completion of this breeding demonstration will show that it is feasible to install breeder cores in existing and future pressurized water reactors and will provide the basic technology which can be used directly in large-scale light water breeder applications.

High-Temperature Gas-Cooled Reactor

During 1970, work continued at Gulf Energy and Environmental Systems, San Diego, Calif., and at Oak Ridge National Laboratory on the high-temperature gas-cooled reactor (HTGR) concept which operates on the thorium-uranium fuel cycle and uses helium as a coolant. The HTGR concept offers the near-term prospect for substantial improvement in fuel utilization, and reduced sensitivity to raised ore costs, because of the high-efficiency, high-temperature steam cycle.

The 40–Mwe. Peach Bottom gas-cooled powerplant was successfully refueled during 1970 and has been operating continuously since the refueling.

Helium has special advantages as a coolant for fast breeder reactors: (*a*) It does not interact with the fast neutrons, thereby simplifying reactor control and enhancing the breeding process; (*b*) helium is transparent and chemically inert, thus providing visibility during refueling and maintenance operations; and (*c*) it makes possible simpler engineering design and, because helium is inert, freedom from



The Fort St. Vrain Nuclear Generating Station, a 330-Mwe. high temperature gas-cooled thermal reactor (HTGR) at Platteville, Colo., is approximately 80 percent complete, and is scheduled to begin commercial operation in early 1972. It is being built by Gulf General Atomic (Gulf Energy and Environmental Systems, Inc.) and the Public Service Co. of Colorado. The reactor is housed in a prestressed concrete vessel—the first of its kind in the U.S. The plant represents an extrapolation of HTGR technology demonstrated in the Philadephia Electric Co.'s Peach Bottom (Pa.) Plant No. 1.

corrosion problems. In a gas-cooled fast breeder, the reactor core, helium circulators, and steam generators could be contained in a prestressed concrete reactor vessel similar to that planned for the commercial 1,100-Mwe. high temperature gas-cooled reactor, thus simplifying development. It also appears to be possible to couple a gas-cooled fast breeder reactor with a direct-cycle gas turbine.

Molten Salt Breeder

During 1970, work continued at the Oak Ridge National Laboratory to develop the technology of molten salt breeder reactor systems. The molten salt reactor concept, when combined with an onsite fuel reprocessing plant, has the potential for achieving attractive fuel costs and fuel doubling time as well as high plant thermal efficiency.

The technological development program covered a wide spectrum: continued development of reactor structural and moderator materials; fuel reprocessing concept definition; reprocessing chemistry, component, system and materials development; studies of possible methods of control of tritium; plant design studies; reactor system technology studies; and postoperation examination of the Molten Salt Reactor Experiment which came to a successful conclusion on December 12, 1969. A request for proposals has been issued for an industrial contractor design study of a 1,000-Mwe. molten salt breeder reactor plant.

There was also a significant increase in privately funded efforts relating to this concept during 1970. The Molten Salt Breeder Reactor Associates, an association of five electrical utilities and a consulting engineering firm, completed Phase 1 of their study of large molten salt power reactors. In addition, 15 electric utilities and six industrial companies formed the Molten Salt Group and began a study of the molten salt reactor concept.

DESALTING AND PROCESS APPLICATIONS

The AEC's nuclear desalting program is 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. The Oak Ridge National Laboratory (ORNL) provides technical support to programs of both the AEC and Office of Saline Water.

An energy center concept study, based on nuclear power in Puerto Rico, was completed in 1970, and the results are being evaluated. Interest has been exhibited by California utilities and water agencies in developing plans for a large-scale nuclear desalting demonstration project.

A conceptual design and economic analysis of industrial and agro-industrial complexes [9] based on large nuclear power-desalting plants applied to the Middle East area was essentially completed in 1970.

ENGINEERING CODES AND STANDARDS

Careful and systematic planning and high standards in each phase of development, design, procurement, construction, manufacturing, fabrication, inspection, installation, test, and operation of nuclear powerplants and test facilities are prerequisites for assuring the safety, reliability, and economy of the AECs reactor development programs and projects. Several years ago, the AEC established a special program for the development of nuclear engineering standards, and quality assurance practices applicable to the AEC's reactor and test facilities.

Approximately 90 approved standards were available to the nuclear industry at the end of 1970. During the year, additional standards were developed covering special requirements of materials (*e.g.*, zirconium, zirconium alloys, and sodium) for nuclear application. More than 100 additional standards are now in various stages of preparation.

AEC and contractor personnel actively participated and assisted in the development of engineering standards by professional societies, including the American Society of Mechanical Engineers, the American Nuclear Society, and the American National Standards Institute (ANSI). Engineering standards activities for both developmental AEC-owned and licensed reactor facilities were coordinated with those of ANSI and the professional societies to the maximum extent possible.

NUCLEAR SAFETY

Nuclear reactors must be designed and built to operate safely, reliably, and economically. The AEC sponsors a general nuclear safety technology program, plus special safety efforts associated with particular reactor concepts. The current concept-oriented reactor safety programs are associated with the LMFBR's of the future as well as the light water reactors now in operation or under construction or planned.

LMFBR SAFETY

Particular emphasis is being placed on the safety aspects of the liquid metal fast breeder reactors to achieve a thorough understanding of these systems and the physical phenomena and processes per-

[9] See pp. 98–99, "Annual Report to Congress for 1968."

taining to the prevention of accidents. The required levels of safety and reliability can be attained with reasonable economy for these systems through excellence of engineering and design as well as quality assurance for construction, fabrication, assembly, test, and operation.

Significant progress has been achieved in the LMFBR safety effort through the development of theoretical analysis techniques and fundamental experimental investigations, as well as through simulation experiments conducted in the Transient Reactor Test (TREAT) at NRTS relative to fuel behavior under postulated accident conditions.

The safety effort is concerned with fuel element failure characteristics, the potential for fuel element failure propagation, and fuel-coolant thermal interactions which might lead to significant pressure pulses, coolant voiding and fuel melting. Other priority LMFBR safety efforts are concerned with fuel assembly integrity, potential

A Plutonium-Uranium Fuel Core is shown under assembly on a split-table machine for measurement of its critical mass. Processing and fabricating operations for a liquid metal fast breeder reactor (LMFBR) industry will involve thousands of kilograms of fuel daily; potentially hundreds of critical masses will be handled. Because of the plutonium content of these fuels, chain reactions under both normal and accident conditions must be avoided. Criticality considerations bear heavily on the safety and economics of the operations and it is important that these considerations be based on accurate, reliable data. A series of criticality experiments with homogeneous mixtures of plutonium and uranium initiated at the Pacific Northwest Laboratory (PNL) in support of the LMFBR program are now being carried on by the Hanford Engineering and Development Laboratory.

accident definition, dynamic structural response of the reactor system safety instrumentation, and post-accident heat removal.

Safety experiments are being conducted on the Fast Flux Test Facility (FFTF) project to take advantage of the firm design orientation which it offers. The FFTF characteristics are such that the safety information applicable to it is also generally applicable to LMFBR's.

Safety-Related Studies

Coolant dynamics is one of the important areas under study because a sodium void could cause an increase in reactivity. One theoretical means of creating a rapidly increasing sodium void is by heating sodium significantly above its boiling point (superheat) before flashing from the liquid to the vapor phase. Early tests, using extremely pure sodium, indicated there was a potential for significant superheat, very rapid sodium voiding, and consequent rapid reactivity increase. However, tests conducted in 1970 by Atomics International, Argonne National Laboratory, and Brookhaven National Laboratory, using conditions more nearly matching an actual reactor system, indicated that superheat can be regarded with significantly less concern.

In studies of fuel element failure propagation, out-of-reactor tests at Argonne National Laboratory indicated that the potential propagation of fuel pin failure caused by the release of fission gas from a failed fuel pin, and consequential blanketing of fuel heat transfer surfaces by this gas is very remote. Further tests are being planned in the Engineering Test Reactor and TREAT at NRTS and in an out-of-reactor facility at ORNL.

The bulk of the in-pile safety work in 1970 was performed in the TREAT facility in Idaho. Two major types of transient tests are being performed. One simulates loss-of-flow situations; the other simulates over-power conditions. Either condition, if not checked, could lead to coolant voiding and fuel melting. Results to date indicate that the thermal interaction between molten fuel or fuel cladding and liquid sodium leads to significantly lower pressure pulses than would be calculated using theoretical, upper-limit assumptions.

Analyses of reactor designs are being performed through the use of accident analysis computer codes. The codes are also being used to help plan and analyze some of the safety tests. A computer code (Rexco) has also been developed at Argonne calculating the response of LMFBR containment vessels and internal components if subjected to large energy releases as in a reactor excursion accident.

412–406—71——12

Theoretical and experimental studies of the behavior of plutonium-uranium-sodium aerosols within a reactor containment building following a postulated major accident in an LMFBR were made by Atomics International and Brookhaven National Laboratory during 1970. Results indicate that the bulk of the airborne material will condense rapidly, form larger particles through the process of agglomeration, and settle out on the horizontal surfaces.

Since sodium is the primary coolant to be used in the LMFBR's, predictive techniques and a computer code have been developed by Atomics International to calculate the characteristics and consequences of postulated large sodium pool fires.

WATER REACTOR SAFETY

Water reactor safety research is concerned primarily with the assurance of safe plant design and operation and with guaranteeing

Glass Raschig Rings can be used as a method of preventing an accidental chain reaction as the result of criticality experiments at the Pacific Northwest Laboratory have shown. For the studies, plutonium solutions were placed in vessels along with glass *Raschig* rings containing boron. The boron absorbed the neutrons released in the fission of the plutonium and prevented the occurrence of a chain reaction. Data from experiments such as these demonstrate the effectiveness of the improved methods for safe and economic handling of plutonium and uranium solutions throughout the nuclear industry.

public safety. This includes examining the integrity of the primary coolant system through the development of strict standards, codes, and criteria, development of technology which forms the basis for quality assurance, potential accident behavior and demonstration of engineered safety features to prevent or arrest accidents.

Water Reactor Safety Program Plan

A report on the water reactor safety program plan was published early in 1970.[10] Prepared by the Water Reactor Safety Program Office, an independent staff administered by Idaho Nuclear Corp., the plan brings together all of the current safety-oriented research for water reactors being funded by the AEC. Comments from industry and the various regulatory bodies were incorporated in the plan.

A valuable contribution of the plan is that it assigns priorities to each of the projects, which facilitates the allocation of funds and provides guidance to the nuclear industry for assuming the research burden as the Government's effort on water reactor safety is being reduced, and increased emphasis is placed on industry-supplied research, including cooperative efforts with the AEC whenever possible.

Primary System Integrity

The principal activities involved in assuring the integrity of reactor primary coolant systems are the heavy section steel technology program (HSST), studies of stainless steel, and the standards program (see previous "Engineering Codes and Standards" item).

The HSST program is managed by an office at Oak Ridge National Laboratory (ORNL) and involves a structural steel irradiation program at Pacific Northwest Laboratories (PNL), many AEC contractors including the U.S. Naval Research Laboratory (Washington, D.C.), and close coordination with collateral industrial research. The objective of this program is to complete the understanding of behavior, under operating conditions, of thick sections of steel now being incorporated in the design of the large light water power reactors. Extensive data on these steels are being accumulated to confirm or modify design theories and to develop criteria for evaluating reactor vessel designs.

---

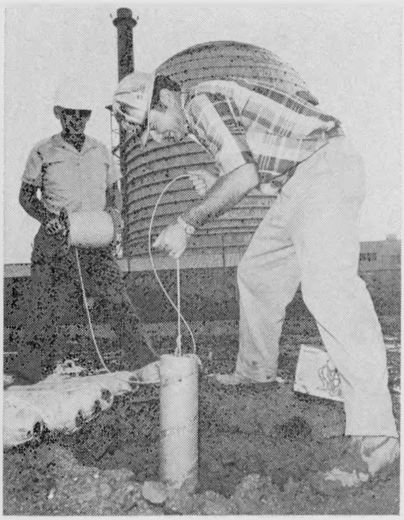
[10] Available (as "WASH–1146") from the National Technical Information Services, U.S. Department of Commerce, Springfield, Va. 22151, for $3 a copy.

Studies at the Naval Research Laboratory have shown that Type–A533 steel can be tailored for high radiation embrittlement resistance by special melt specifications, including reduction of copper and phosphorus impurities to very low levels (0.03 and 0.008 percent, respectively).

Studies were started at Battelle Memorial Institute (Columbus, Ohio) to obtain engineering data concerning the effect of stress level, oxygen content, heat treatment, and type of material on failure behavior and rate of stress-corrosion cracking in various stainless steels now in use or for potential application to reactor primary systems. Similarly, under studies by General Electric (San Jose, Calif.) of primary piping, a test loop was added to the Dresden (Ill.) Nuclear Power Station—Unit 1 reactor coolant system to obtain engineering data on the effect of normal boiling water on the fatigue and static behavior of various reactor piping and pressure vessel materials. Spare test space in the loop was also made available to industry for insertion of materials of individual interest.

Seismic Research

As part of the seismic research program vibration tests were conducted at the Experimental Gas-Cooled Reactor at Oak Ridge by the University of California at Los Angeles (UCLA) to examine the



Dynamite Charges Were Detonated near a nonoperating, experimental nuclear reactor in Oak Ridge, Tenn., in August as part of tests to increase scientific and engineering knowledge on the safe and economic design of nuclear powerplants located in regions of seismic activity. The tests were carried out under a contract between the AEC and the University of California at Los Angeles (UCLA). In photo, blasting experts lower dynamite charges down deep holes. In the background is the containment shell of the Experimental Gas-Cooled Reactor (EGCR) a project which was terminated by the AEC in 1966 prior to completion and operation of the reactor. Instruments placed throughout the reactor provided researchers with data on the response of the building and its equipment to the underground charges.

suitability of using chemical explosives to simulate seismic ground motion, particularly strong motion approaching that of severe earthquakes. Strong ground motion simulation is desirable to permit determination of the response characteristics of reactor structures and major components (such as cores, containment shells, pressure vessels, and steam generators), including possible effects of large strain and nonlinearity on damping and structural deformations; the ability of analytical models to predict such behavior is also being analyzed.[11]

Related to seismic vibration, the U.S. Coast and Geodetic Survey completed a study of microtremors in Caracas, Venezuela, which examined the possible effect of local amplification of seismic motion and attempted to correlate local effects with pockets of unexpectedly severe structural damage experienced in Caracas in the 1967 earthquake. Also under the seismic program, new studies were begun by the U.S. Geological Survey (USGS) to develop regional maps correlating seismicity and geology in the southwestern United States and other regions to form a standardized basis for evaluating the seismic characteristics at proposed reactor sites. In addition, the USGS completed a prototype environmental geologic map of the Los Angeles basin, summarizing information as an aid to determining the suitability of potential reactor sites and to making safety evaluations of such sites. Additional maps will be made of other California coastal areas.

Containment Systems Experiment

The containment systems experiment (CSE) project at the Hanford Works was terminated. Reports were issued on the various experimental areas; containment leakage, loads on internal reactor components, fission product transport, and the effectiveness of engineering safety features in scavenging fission products to prevent their release to the environment.

These reports included, for example, results of CSE containment spray tests which indicated that concentrations of elemental iodine among any fission products released to the containment (such as that of a large pressurized water reactor) by a reactor accident could be reduced to one-fiftieth of the original amount within 2 hours if a caustic-borate spray was used, and to less than one-hundredth if sodium thiosulfate was added to the spray. On the other hand, any methyl

[11] The ninth in a series of status-of-technology reports, "Earthquakes and Nuclear Power Plant Design" (ORNL–NSIC–28), was published in July by the Nuclear Safety Information Center at Oak Ridge National Laboratory. It is available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151, for $3 a copy.

iodide which formed from the fission product iodine and organic vapors would be reduced only about one-third in 2 hours and about one-eighth of the original amount in 24 hours. Particulate fission products, such as cesium and particulate uranium, also would be reduced in 2 hours to about one-twentieth and one-tenth of the original amounts respectively. CSE blowdown experiments correlated fluid flow rates with mathematical models and tests of other investigators and developed a prediction for nozzle and discharge coefficients as a function of the ratio of areas of the nozzle and vessel cross-sections.

Emergency Core Cooling

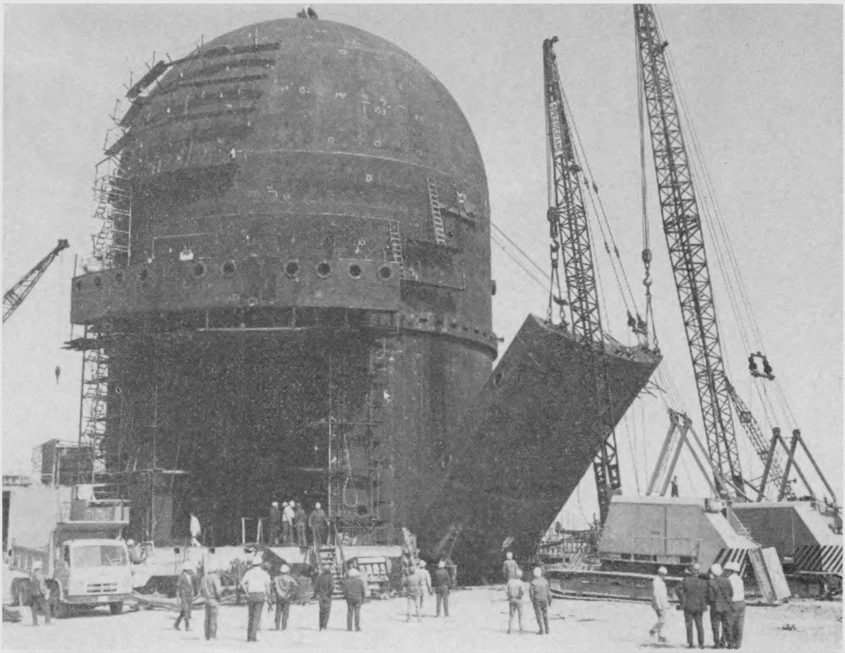
Various emergency core cooling activities are in progress as part of an engineering test effort related to potential behavior of emergency cooling systems under highly unlikely, but postulated, loss of coolant accidents. For example, tests of emergency cooling capability were completed under a full-length emergency cooling heat transfer project using full-size (12 ft. long) simulated fuel pin assemblies by General Electric (San Jose, Calif.) and Westinghouse (Waltz Mill, Pa., facility) under subcontract to Idaho Nuclear Corp. These tests used electrically heated assemblies simulating full-size reactor fuel pins cooled by sprays and flooding. They were performed to assess the degree of confidence in emergency cooling systems under design and off-design conditions. Most of the tests indicated that emergency core cooling systems, as designed, will perform their intended function over a wide range of cooling and temperature conditions. In some tests, with conditions at higher zircaloy cladding temperatures than usually proposed, a considerable amount of metal-water reaction damage was observed using spray cooling. Such extreme testing was useful in assessing the limits of performances of spray and in studying the influence of clad temperature at the time of emergency cooling injection.

Safety Test Reactors

Progress continues on the design and construction of the 55 Mwt. Loss of Fluid Test (LOFT) facility at the National Reactor Testing Station. By the end of 1970, construction was over 55 percent complete; initial operation is scheduled for late 1973.

LOFT is a test facility in which major loss-of-coolant accident experiments can be carried out under controlled conditions with all of the accident initiation, response, and consequence phenomena present, while incorporating the variables of an operating light water nuclear reactor. The LOFT program objectives are to: (*a*) Evaluate the adequacy of analytical techniques for assessing performance of engineered safety systems; (*b*) evaluate the performance and safety margin of engineered safety systems; and (*c*) identify unexpected events not presently evaluated or included. The major contractor for LOFT is the Idaho Nuclear Corp.

The Power Burst Facility (PBF) is a safety-test reactor being constructed at NRTS as part of the Special Power Excursion Reactor Test (SPERT) complex. The project is under the technical direction of



Workmen are Dwarfed by the 200-ton Door being lifted into place for the Loss of Fluid Test (LOFT) containment building now 92 percent completed at the National Reactor Testing Station in Idaho. Two 8-wheel flatbed trailers were used to transport the huge structure from a nearby area where it was fabricated. Photo shows the door partially pulled into position with the help of two 60-ton cranes. The door is designed to sit on trucks which slide along rails to provide access through the containment building opening (black area behind platform) for a double-width railroad flatcar that will shuttle the LOFT reactor between a large hot shop and the test building. LOFT testing will study the capability of emergency nuclear core-cooling systems to prevent core damage—and subsequent radioactivity release into the containment shell—during experiments in which the reactor's coolant will be suddenly "lost" through a simulated break in the primary system piping. The tests are scheduled to begin in 1973 following completion of the facility and test equipment. The LOFT program at NRTS is assigned by the AEC to Idaho Nuclear Corp.; construction is being performed by Idaho Nuclear, Howard S. Wright and Associates, and Pittsburg-Des Moines Steel.

Idaho Nuclear Corp; Howard S. Wright (Seattle, Wash.) is the construction contractor.

The primary purpose of the PBF is to study fuel behavior under overpower and loss-of-coolant conditions. The fuel assemblies are 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. Fuel loading is scheduled for the summer of 1971.

SUPPLEMENTAL RESEARCH REPORT

Fundamental nuclear reactor development and technology programs that are sponsored by the AEC are summarized in the supplemental report, "Fundamental Nuclear Energy Research—1970." [12] Some of the key achievements, covered in somewhat greater detail in Part Two of that report, include:

Nuclear Fuels and Materials

- Oxide fuels appear substantially weaker during irradiation as a direct result of the fission process, and fuel element swelling has been shown to be a linear function of burnup or time.
- Tests show sodium-bonded mixed nitride fuel should have a burnup potential of 159,000 megawatt days per ton (MWD/T), or more than 50 percent greater than the generally accepted goal for LMFBR fuels of 100,000 MWD/T.
- Element composition changes and preirradiation treatment have a significant influence on radiation-induced microstructural and volume changes in stainless steel.
- A new technique to measure thermal conductivities and surface tensions for molten salt and alkali-metal reactor coolants shows thermal conductivities of several important fluoride mixtures are only one-third as high as previously supposed. For the first time, surface tensions for cesium were measured to 600° C.
- Experimental evidence indicates flow rate has an important effect on the degree of incipient boiling superheat in alkali liquid metals; as flow rate increases, the high superheats found under static conditions are greatly reduced.

---

[12] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $2.75.

Reactor Physics Research

- The accuracy and energy resolution of the neutron inelastic-scattering measurements have been improved to the extent that the high energy region, in which isotope excitation levels are so close as to be unresolved, can be examined in considerable detail. This has resulted in the discovery that, at least for some elements, the behavior of the neutron-neutron cross section in this region is not as had been anticipated.
- The number of prompt neutrons released per fission varies with incident neutron energy and is correlated with spins of the fission resonances. Experimental techniques to measure prompt neutrons with great precision show the variation from resonance to resonance to be as much as 30 percent for plutonium-239, 0.6 percent for uranium-235 and about 0.2 percent for uranium-233.
- Half-life measurements of a high purity sample of plutonium-241 over 2½ years show the rate of early experiment decay was higher than that during latter stages, suggesting the presence of a substance in the sample which decays with a half-life of approximately 0.3 year. The data indicate existence of a previously unsuspected isomeric form of this isotope.

Chapter 7

SPACE NUCLEAR SYSTEMS

The AEC's activities in the Nation's space exploration effort include the research and development of nuclear rocket propulsion systems for advanced space missions, the development of small nuclear reactors and isotopic systems—the first such unit (SNAP–3A) is in its 10th year of operation—for the generation of electric power in space, and specialized isotopic heat source systems for a variety of uses. Most of the work is done in cooperation with the National Aeronautics and Space Administration (NASA).

NUCLEAR ROCKET PROGRAM

The nuclear rocket program is a joint endeavor of the AEC and the National Aeronautics and Space Administration (NASA) to provide a significant increase in propulsion capability for future space activities. The major objective is to develop a 75,000-pound-thrust engine, called NERVA (which stands for Nuclear Engine for Rocket Vehicle Application), for space flight missions. The program also includes a variety of advanced and supporting research and technology activities in which the aims are to extend the technology, to improve nuclear rocket performance, and to investigate advanced propulsion concepts.

PROGRESS IN NERVA DEVELOPMENT

The year 1970 was marked by the transition from completion of the NERVA technology program to the initiation of the definition phase for an operational nuclear rocket engine for mission use. The technology program, which was completed in 1969,[1] was designed to

[1] See p. 165, "Annual Report to Congress for 1969."

investigate the performance potential, demonstrate the capabilities of nuclear rocket engines, and establish a foundation of performance data from which engine characteristics best suited to mission requirements could be selected. It successfully met these goals. Based on this work, the development of the flight-rated NERVA engine was initiated.

NERVA development activities concentrated on the definition and preliminary design of the flight-rated NERVA engine. Performance goals have been established at 75,000-pound thrust, a duration of 10 hours at rated conditions, multiple restarts, and a specific impulse [2] of 825 seconds. The NERVA engine, as defined, could be used in a variety of missions, including the nuclear shuttle space transportation system recommended by the President's Space Task Group.

Design Review Started

Nuclear subsystem design and development activities for the NERVA engine are concentrated at the Westinghouse Astronuclear Laboratory (WANL) at Large, Pa. The WANL nuclear subsystem activities during the year, in association with related efforts on the engine system and nonnuclear components at Aerojet Nuclear Systems Co. (Sacramento, Calif.), were aimed at a major event in the NERVA timetable: the preliminary design review. This formal design review started in October 1970 and is expected to be completed by early 1971. The review provides the opportunity for critical study of the materials, design, and test data and permits evaluation against the performance and reliability criteria defined for the NERVA system. In the months immediately following, designs will be confirmed, residual alternatives narrowed, and detailed component and specifications established leading to the fabrication cycle to be initiated in 1971.

During 1970, detailed "trade" studies were completed on candidate critical components for the nuclear subsystem. Materials for the various critical components including reflector, shield, stem support, and periphery, were tested and evaluated and selections made. For example, design is proceeding on a segmented beryllium reflector with aluminum support. Dimensions of the reflector system were the most suitable with respect to fuel reactivity, system weight, and reactor controllability. Based on analysis and material testing, WANL has proceeded with the design of a flight prototype shield composed of a

---

[2] *Specific impulse*—A term used by propulsion engineers which is equal to the exhaust velocity divided by the acceleration due to gravity.

materials aggregate of boronated aluminum, titanium hydride, and lead. It will be configured and proportioned to provide the best possible shielding for the engine system components, propellant tankage, and crew.

Fuel Element Development

In addition, substantial emphasis was placed on development of fuel elements to meet the 10-hour duration and multiple cycling performance goal of the NERVA flight engine. As the nuclear fuel is the most critical part of the nuclear subsystem, a rigorous fuel development program was pursued in several areas. The fuel element work is concentrated on two matrix materials: bead-loaded graphite, and a graphite plus carbide composite. The former incorporates innovations in design and production processes reflecting the experience gained from laboratory evaluation and ground testing in prior reactors. The composite comprises a dispersion of the mixed carbide in a graphite matrix which, in laboratory studies to date, has shown considerable promise for extended corrosion endurance under the cyclic operation required for the NERVA reactor. These composite fuel elements successfully completed 10 hours of electrical corrosion testing, including 60 thermal cycles.

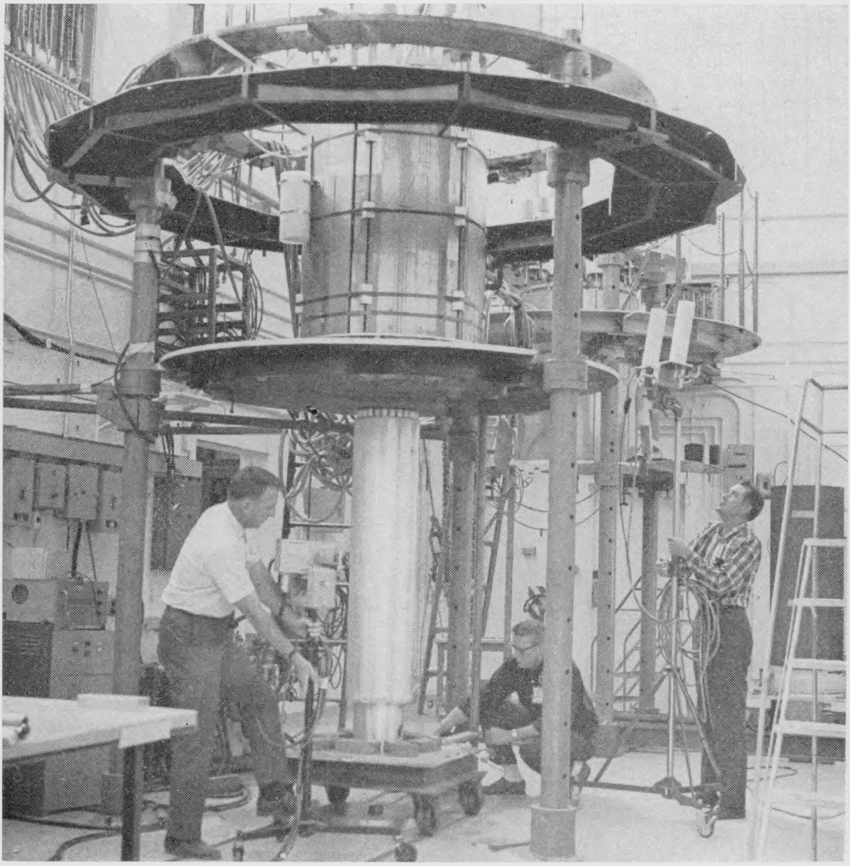
Pewee-2 Reactor Tests

Fuel elements of both types were fabricated and a series of laboratory tests conducted during the year. Both types were fabricated in 1970 for incorporation into a small experimental test reactor called Pewee-2. The Pewee-2 reactor was assembled at Los Alamos Scientific Laboratory (LASL) and shipped to the Nuclear Rocket Development Station (NRDS) in Nevada. Performance data from this small experimental reactor, which will be tested in 1971, will be used in making the selection of the best fuel element for the NERVA flight reactor series.

The development and fabrication departments of the AEC's Y–12 Plant (Oak Ridge, Tenn.) and the Los Alamos Scientific Laboratory, cooperated with WANL in these endeavors in Pewee-2 and NERVA development. All the bead-loaded graphite activities were pursued at Oak Ridge, whereas all composite development, based on LASL technology, was concentrated at Los Alamos and the Westinghouse fuel facility.

ADVANCED RESEARCH AND TECHNOLOGY

The effort in advanced research and technology is directed toward improvement of the performance of nuclear rockets by increasing the operating time and operating temperature for solid-core reactors, and by investigation of advance propulsion concepts. The major activi-



The Nuclear Furnace, designed and built at the Los Alamos Scientific Laboratory, will be used to evaluate fuel elements under fairly realistic conditions. In addition to its test capability that more nearly duplicates the actual operating environment of a propulsion reactor, the turnaround time for testing with the nuclear furnace is shorter than the Pewee reactors. Design of the nuclear furnace allows recovery of all parts except the fueled can with its fuel elements and the pressure vessel dome which must be disposed of after the test. The geometry of the core is such that studies of individual elements are possible. The first tests on composite and carbide fuels with the furnace are scheduled for 1971 at the Nuclear Rocket Development Station in Nevada.

ties are: (*a*) The research, development, and laboratory evaluation of improved fuel elements and other special reactor materials; (*b*) reactor fabrication and testing to evaluate both elements and reactor design features; and (*c*) research and experimental work on advanced fission and fusion propulsion concepts. This work is concentrated at the Los Alamos Scientific Laboratory in New Mexico.

Fuel Element Testing

In addition to the fuel element work described earlier, work also continued on the development of evaluation techniques for the composite and carbide fuel elements. The design of a nuclear furnace to be used for fuel element development and evaluation was completed. The furnace provides a fuel-element test bed to explore and simulate the necessary operating conditions of time, temperature, and cycles that duplicate the fuel experiences in a reactor but which are difficult to simulate in the existing electrically heated corrosion test furnace. The first nuclear furnace test will provide a more realistic method of testing these elements.

During 1970, fabrication of the parts for the first nuclear furnace test was initiated. In addition, fabrication of the hardware for the modification of test cell "C" at the NRDS to test the first nuclear furnace was initiated.

Efforts also continued during the year to improve reactors and core designs to determine the best use of solid solution carbides.

Plasma Arc Research

In the area of advanced propulsion, fundamental research was conducted on plasma arc and other advanced concepts. In plasma arc research, substantial progress was made in experimentally producing a specific impulse of approximately two to three times that achieved in solid-core rockets.

SPACE POWER AND HEAT SYSTEMS

The objective of the space electric power program is to provide the operational systems and the advanced technology development which will satisfy the need for nuclear electric power in space applications. During 1970, the major program emphasis was on operational systems for current national space program; *i.e.*, the Transit generator for the Navy Navigational Satellite, a modified SNAP–19 [3] generator

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

for NASA's Pioneer Jupiter flyby and Viking Mars lander missions. Effort was also continued on several other technology areas which are candidate systems for future space missions—zirconium hydride reactors and isotope Brayton [4] systems, thermionic [5] reactors for future high-power missions, and a multi-hundred-watt radioisotope generator for outer planet and earth resources applications.

ISOTOPE POWER SYSTEMS

Isotope power systems were used on several space missions during the 1960's (as illustrated on Table 1) and their use will increase during the 1970 decade. Currently effort is underway on three applications (Pioneer, Viking, and Transit) for NASA and the Department of Defense (DOD). Several other missions which are also being considered by the user agencies will require isotope power systems; *e.g.*, unmanned missions to the outer planets and earth-orbit missions with particularly stringent mission requirements. The goal of the AEC's isotope power development program is to meet the needs of both the current programs and the potential longer term applications. However, only minimal effort is being expended on the long-term technology programs.

TABLE 1.—ISOTOPE POWER SYSTEMS FOR SPACE

Designation	Prime contractor	Application-user (Launch date)
Launched:		
SNAP-3A	Martin Marietta	Navigational Satellites-DOD (1961).
SNAP-9A	Martin Marietta	2 Navigational Satellites-DOD (1963).
SNAP-19	Martin Marietta	Weather Satellite-NASA (1969).
SNAP-27	General Electric	Lunar Experiments-NASA (1969).
Under development:		
Pioneer	Isotopes, Inc	2 Jupiter Probes-NASA (1972-73).
Viking	Isotopes, Inc	2 Mars Landers-NASA (1975).
Transit	TRW	Navigational Satellite-DOD (early 1970's).

Operating Systems in Space

Both the SNAP-27 and the SNAP-19 systems which were put into use during 1969 achieved 1 year of continuous operation during 1970.

[4] *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.

[5] *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.

Apollo 12. The SNAP–27 power supply system deployed on the moon by the Apollo 12 astronauts in November 1969 [6] has performed extremely well and is now producing 73 watts (higher than the mission requirement). The stable operation of the SNAP–27 thermoelectric unit has enabled the Apollo Lunar Surface Experiments Package (ALSEP)—an automated scientific measurements laboratory—to operate uninterrupted during both the lunar day and 14-earth-day lunar night and will allow continued operation as long as the experiments themselves are functional. Important scientific information is being received which will aid in understanding the structure, evolution and history of the moon. An additional SNAP–27 has been ordered by NASA and will be delivered in 1971.

Apollo 13. The Apollo 13 mission which was launched on April 11 and then aborted prior to reaching the moon, carried with it a SNAP–27 unit. The plutonium-238 heat source traveled with the crippled spacecraft around the moon and reentered with it into the earth's environment. The transport cask which contained the heat source had been designed to protect the source through reentry conditions so that the plutonium fuel would not be spread through the atmosphere but would impact the earth's surface intact. Monitoring surveys taken in the vicinity of the reentry have confirmed that the transport cask functioned as designed and that the capsule is resting on the ocean bottom at a depth of approximately 20,000 feet somewhere between Tonga and Rau Islands in the south Pacific Ocean.

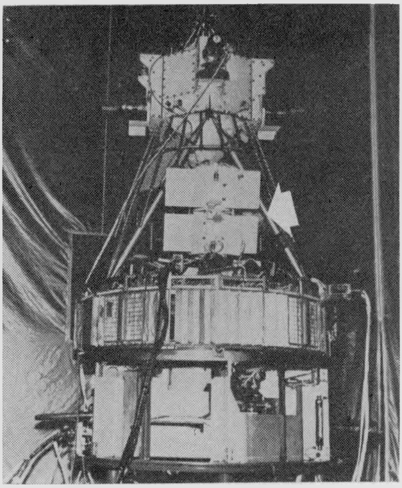
SNAP–19 and 3A. The SNAP–19 is also performing well (though it has experienced some performance degradation) and is providing the supplementary power required for the NIMBUS–III weather spacecraft experiments which were launched in April 1969.

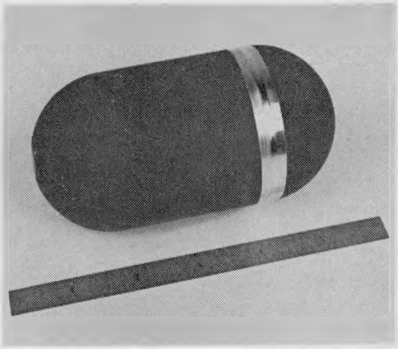
The other systems which were launched in early years are still continuing to operate though at significantly reduced power levels. The grapefruit sized SNAP–3A, the first isotopic generator to be orbited in space, has now been in continuous operation aboard a navigational satellite for over 9 years.

Transit Generator

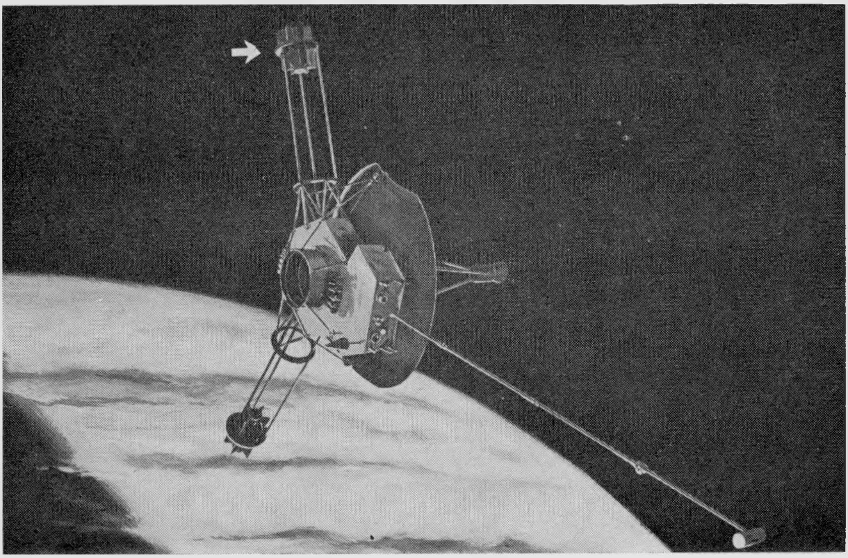
Fabrication and testing of the 5-year-life Transit generator for the Navy's advanced navigational satellite was continued by TRW Systems (Redondo Beach, Calif.). The first complete, electrically heated unit was fabricated and tested and will be delivered to the Navy

[6] See pp. 17–18, 176 of "Annual Report to Congress for 1969."





SNAP–19 *Radioisotope Thermoelectric Generators* (RTG), already in orbit for more than a year-and-a-half, are also being modified for probing the planet Jupiter in deep outer space. Photo at *upper left* shows the pair of SNAP–19's (*arrow*) aboard NASA's Nimbus III weather satellite which was launched April 14, 1969. At the end of 1970, the two generators were still 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. Modified SNAP–19 generators will be used for NASA's Pioneer space probes of the planet Jupiter in 1972 and 1973. Mound Laboratory is developing and fabricating the fuel capsules and radioisotopic heaters that will be used for man's first scientific venture past Mars in the solar system. Pictured at *upper right* is the 4-inch-long Pioneer fuel capsule. Heat produced by the decay of plutonium-238 will be converted by a thermoelectric generator to power instrumentation aboard the unmanned spacecraft shown in artist's concept *below;* a modified SNAP–19 is indicated by the arrow. The 1-thermal-watt radioisotopic heaters will also be used to warm the hydrazine propellant.



for spacecraft integration efforts early in 1971. Fabrication of a complete isotopically fueled ground-test unit was continued with testing scheduled to begin early in 1971.

Pioneer Generator

The design of the modified SNAP–19 generator for application with NASA's Pioneer Jupiter mission was completed during 1970 by Isotopes, Inc. (Timonium, Md.) and electrically heated prototype generators were delivered to NASA. Fabrication of four isotopically fueled prototype generators for NASA spacecraft integration efforts was also near completion and these generators are scheduled for shipment early in 1971. Pioneer launches are scheduled in 1972 and 1973. Use of nuclear power on this mission reduces total power system weight and eliminates uncertainties concerning operation at extended distances from the sun which would be inherent with the use of solar array systems. The reduced weight allows for including additional scientific packages which increases the total value of the mission itself.

Viking Generator

Early in 1970, the Viking program launch dates were deferred from 1973 to 1975. Consequently the Viking effort by Isotopes, Inc., was reduced and primarily directed toward spacecraft integration.

Multi-Hundred-Watt Generator Module

The multi-hundred-watt generator will form a basic building block for space power systems in the 100- to 1,000-electrical watt range. Certain specialized DOD satellites in this power range will require this type of nuclear power system. Missions to the outer planets will also require nuclear power, and the current planning indicates that this system will be best able to meet the projected power requirements. Preliminary design studies were completed by General Electric (Valley Forge, Pa.) and fabrication of test components was initiated—leading toward a fueled-module demonstration in the 1973–74 time period.

Isotope Brayton System

NASA has given considerable emphasis to development of a plutonium-238 fueled radioisotope Brayton system for application in the electrical power range of a few kilowatts. The AEC has been pursuing the development of the fueled isotope capsule for application with this system. A nuclear safety feasibility study was conducted by the AEC with participation by both AEC and NASA laboratories.

ISOTOPE HEAT SOURCES

Relatively large amounts of heat generated during the radioactive decay process in radioisotopes can be used productively by converting it to electrical or mechanical power. The isotopes fuel development activities develop and test radioisotope fuel forms and heat sources to assure that in practical applications they will be both effective and safe.

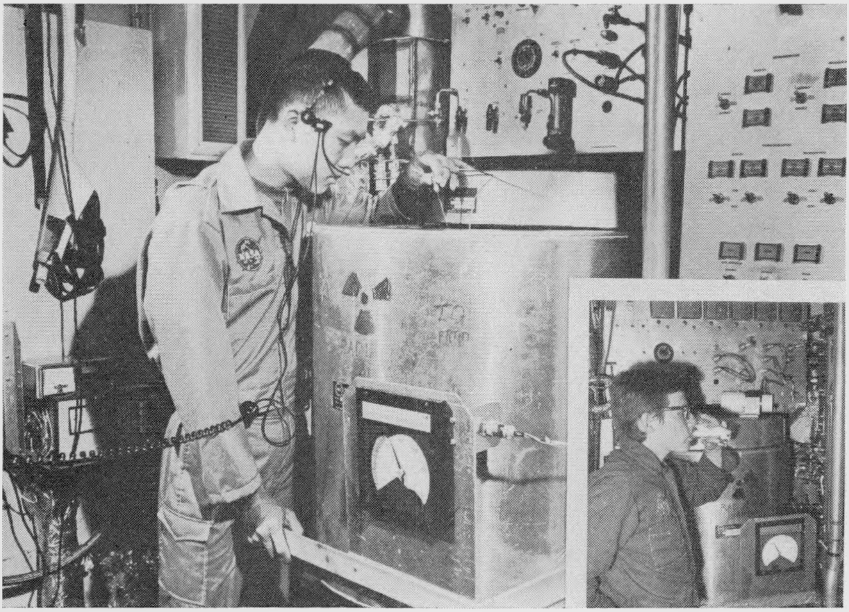
Plutonium-238 and Curium-244

Plutonium-238 is currently the isotope being used or planned in all major space applications. Efforts are continuing towards development of improved cermet fuel forms and a plutonium-molybdenum cermet fuel form has been selected for use in the Pioneer, Transit, and Viking programs.

A heat source loaded with curium-244, placed on test by the AEC's Oak Ridge National Laboratory, has successfully completed a full year of test operation. Curium-244 will be produced as a natural by-product of the commercial reactors and has the potential of significantly reducing radioisotope fuel costs.

Pioneer Spacecraft Heaters

Progress was made in 1970 in the design, development, and fabrication at Los Alamos Scientific Laboratory and Mound Laboratory of radioisotope heat sources to be employed on the NASA "Pioneer" Jupiter flyby missions planned for 1972–73. These heat sources will be used to prevent freezing of the hydrazine fuel in the spacecraft thruster engines and fuel tank which would otherwise occur at the very low outer-space temperatures. During the year, 19 test and development plutonium-238 fueled heat source capsules were delivered for these missions to the NASA contractor, TRW Space Systems, Inc. (Redondo Beach, Calif.). The AEC effort is proceeding on schedule and it is expected that 22 flight-qualified heat source capsules will be delivered during 1971.



A Most Important Space Application of Radioisotopes may be in providing life-support systems for astronauts. During mid-1970, four men spent 90 days in the space simulation chamber of the McDonnel-Douglas Astronautics Corp., at Huntington Beach, Calif., successfully demonstrating the effectiveness of the AEC's radioisotope-powered water recovery system. All water requirements of the four-man team were provided by recycling waste water through the recovery system, which produced about 1 pound of bacteria-free drinking water per hour from perspiration, respiration, and urine. The unit, developed in cooperation with the U.S. Air Force, was designed and built by Wright-Patterson Air Force Base (Dayton, Ohio) using radioisotope heat sources provided by the AEC's Mound Laboratory which had conducted the early testing of the water purification process. The four crewmen taking part in the 3-month "mission"—the Nation's longest test of a space station-type life support system and the first manned-chamber test using radioisotopes—were specially selected young scientists and graduate students. In large photo a crewman checks the operation of the water recovery system while the inset at *lower right* shows another crewman drinking a glass of the water that was more bacteria-free than ordinary tap water. There are strong incentives for developing methods for recovering and reusing the spacecraft water supply. A four-man team on a 180-day space mission would require nearly 10,000 pounds of water for consumption and personal hygiene. Delivered in space by an auxiliary craft, the water might cost as much as $1,000 a pound. One way to offset this cost would be by electrical heat distillation and sterilization of the recovered waste water. Since it is impractical to provide sufficient electric power on board spacecraft for this, a radioactive heat source offers an effective solution. The radioisotope-powered water recovery system shown *above* uses five plutonium-238 sources producing a total of 342 thermal watts to allow the system—two evaporators, a catalytic oxidation unit, a condenser, and three residue storage tanks—to operate indefinitely without taking precious power or fuel from the spacecraft's power system. The heat from the radioisotope sources is used to distill and purify water from urine, washing, cooking, and other liquid wastes as well as the airborne vapor.

REACTORS FOR SPACE

Reactor systems offer the only practical approach to meeting the high power demands of many future space missions. Current AEC effort has been directed toward two primary reactor systems; *i.e.*, the zirconium hydride reactor for power levels up to around 100 kilowatts (kw.), and the in-core thermionic reactors for power levels in excess of 100 kw.

Zirconium Hydride Reactor

Disassembly of the second generation, high-power, high-temperature uranium-zirconium hydride (ZrH) reactor (S8DR) was completed by Atomics International (Canoga Park, Calif.) during 1970. Testing of the S8DR was begun in late 1968 and the reactor was shut down in late 1969 after about 7,000 hours of power operation. Data collected during operation indicated that cracking of a number of fuel element cladding had occurred. Information obtained during the disassembly and detailed examination of the reactor is applicable to the planned core test which will verify the adequacy of this reactor concept for long-term (several years) operation.

The zirconium hydride reactor can be used with several conversion systems and the AEC is pursuing development of one of these—a compact thermoelectric conversion system. During 1970, thermal distortion of the thermoelectric converter module during operations was eliminated through the use of a refractory metal inner liner. The reactor-thermoelectric system provides a power system of high reliability and simplicity from a few kilowatts up to around 35 kw. of electricity.

Thermionic Reactor

Gulf Energy and Environmental Systems (San Diego, Calif.) was selected as the prime contractor to continue the development of a thermionic[7] fuel element and to fabricate an experimental reactor planned for operation in the mid-to-late 1970's. This reactor will be based on use of fuel elements which convert heat to electricity within the reactor core and which are capable of long endurance operation at extremely high temperatures (*i.e.*, around 3,000° F.). Emphasis is currently being directed toward demonstration of a full-length thermionic fuel element. Supporting technology is being conducted by the AEC's Los Alamos Scientific Laboratory and the Thermo Electron Corp. (Waltham, Mass.).

---

[7] See footnote p. 178.

Chapter 8

ISOTOPIC SYSTEMS DEVELOPMENT

Radioisotopes—besides giving off heat as they decay (see Chapter 7)—also emit alpha or beta particles, or gamma rays, which the AEC and industry have long found useful in a wide variety of applications. Radioisotopes have also been used as small neutron sources. Today, as larger quantities of californium-252 [1] become available, additional uses are developing which take advantage of the intense neutron emission of this manmade isotope.

RADIATION PROCESSING

Exposure of various materials to nuclear radiation can cause chemical, physical, or biological changes, often of a useful nature.

Concrete Polymers

Plastic-concrete composites with vastly improved chemical and physical properties are made when concrete is impregnated with a liquid chemical and then exposed to gamma irradiation. The resulting material is harder than concrete, is almost impervious to freezing and thawing, and is resistant to chemical attack by distilled and salt water. Potential applications include highway construction, housing construction, and concrete pipe manufacture.

During 1970, in a Brookhaven National Laboratory cooperative program with the U.S. Department of the Interior's Office of Saline Water, a chemical, TPT,[2] was found which, when combined with

[1] See also Chapter 4 of this report; pp. 8, 49–50, 189–190, "Annual Report to Congress for 1969"; pp. 39–42, "Annual Report to Congress for 1968"; pp. 40–43, "Annual Report to Congress for 1967"; and p. 100, "Annual Report to Congress for 1966."

[2] TPT—Trimethylol-propane-trimethacrylate.

styrene and impregnated and polymerized in concrete, yields a material suitable for high-temperature applications up to 350° F. This property, along with chemical resistance, can be of value for the con-construction of water desalinization plants. It was also determined that concrete-polymer material was comparable to ordinary concrete in skid resistance, a valuable feature in highway construction.

Paints and Plastics

The properties of paints and liquid plastics are determined to a large extent by how thick or syrupy they are. This, in turn, is a function of the molecular weight or size of the constituent chemical molecules. Nuclear radiation has been found to be effective in permitting careful control of the extent to which smaller chemical molecules are combined into larger ones. Thus, nuclear radiation can be used to "tailor make" paints and plastics with desired properties. Both applied research and pilot plant studies are being conducted at North Carolina State University (Raleigh) to exploit this capability and develop basic ingredients for such "tailored" paints and plastics.

Food Preservation

The application of nuclear radiation to preserve foods is based on the ability of radiation to destroy the micro-organisms that cause food to spoil. The AEC program is directed toward low-dose radiation processing to extend the marketable life of fruits and fish.

New Petitions to FDA

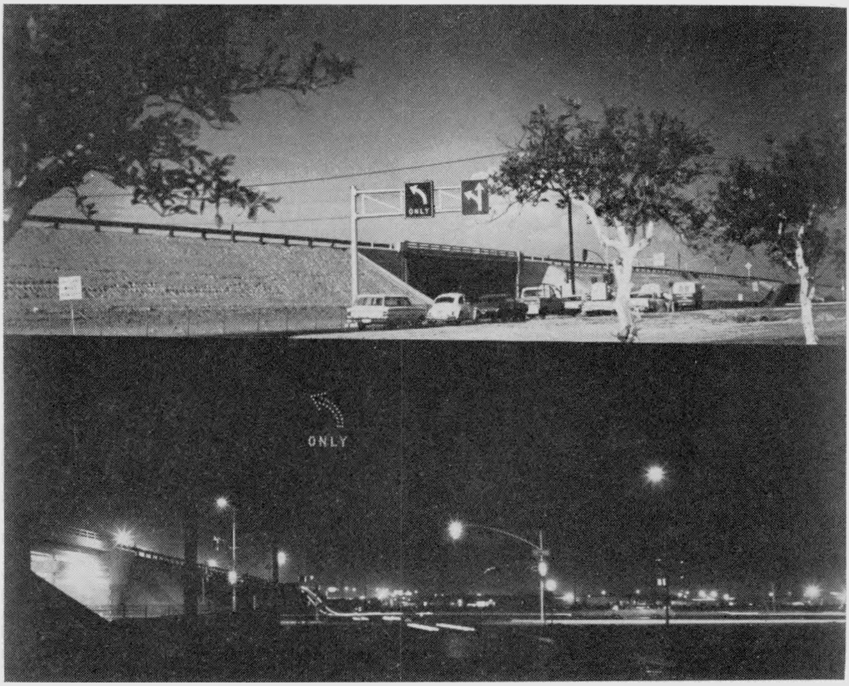
Long-term animal feeding studies were completed in 1970 on strawberries. No adverse effects were observed on wholesomeness. Accordingly, petition is to be submitted in early 1971 to the Food and Drug Administration (FDA) for approval of general public consumption of radiation processed strawberries.

Similar animal feeding studies are continuing on disinfestation of papayas. By yearend, 1½ years of a planned 2-year study were completed, again with no apparent adverse effects. A petition for approval of radiation processed papayas is planned for submission to FDA in 1971.

Animal feeding studies on irradiation-pasteurized fish are scheduled to begin in mid-1971, with petition submission to FDA planned for 1973 or 1974. Overseas, The Netherlands has approved, and begun, commercial marketing of radiation processed mushrooms; consumer acceptance has been excellent.

ISOTOPIC SYSTEMS

Hundreds of applications have been found for small quantities of radioisotopes for tracing and measurement purposes in research and industry. These uses of radioisotopes are based on the ability of in-



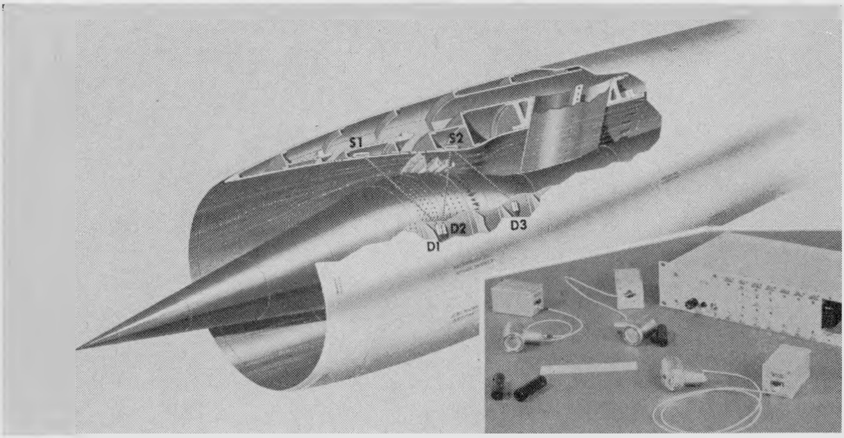
The Arizona State Highway Commission, with the AEC's cooperation, is testing a large left-turn-only highway sign on the access ramp to U.S. Interstate Route 10 (I–10) in Phoenix. The sign is self-illuminating by use of multiple krypton-85 activated light sources. The photo compares the sign's visibility in daylight (*top*) and at night (*bottom*). The sign was fabricated by American Atomics, Inc. (Tucson, Ariz.). The advantages of the isotopic self-luminous sign are that it has relatively low installation costs, consumes no electricity, operates continuously, requires little or no maintenance and is expected to be operable for 10 years. A number of other States have expressed interest. The light-producing capability of radioisotopes has been exploited to develop a variety of self-luminous signs, including exit signs on commercial aircraft. The beta radiation from radioisotopes such as krypton-85 and tritium acts on phosphors to produce light in much the same way that electrons impinge upon a phosphor-coated TV screen to produce an image.

struments to detect and measure the emitted radiation. Radioisotopes can also be used to produce images or light and can be sources of heat energy.

Cement Quality

A radioisotopic method for measuring the cement content of wet concrete mix—before it is poured—has been developed by the Texas Nuclear Division of Nuclear Chicago Corp. (Austin, Tex.). The work was done under an AEC contract in cooperation with the Bureau of Public Roads, U.S. Department of Transportation.

Now, by use of a totally immersible dual-source probe, and through electronic detection of the backscattered energies, an inspector can tell whether the mix contains the specified quantity of cement and is of proper quality to result in a cured concrete of acceptable strength. The probe employs americium-241 as the lesser, and cesium-137 as the more energetic, gamma ray source. By using these two radioisotopic sources, it is possible to offset both density and aggregate-type



Aircraft Safety and Jet Engine Efficiency will be enhanced through an isotopic measurement system that determines the interface position in a mixed compression airflow system. Developed by Industrial Nucleonics Corp. (Columbus, Ohio) under an AEC contract, the system was tested during 1970 at NASA's Ames Research Center (Sunnyvale, Calif.). Photo shows how the sets of krypton-85 beta-ray sources (*S1* and *S2*) and three detectors (D1, D2, and D3) determine inlet air density before, behind, and transversely through the standing shock wave in supersonic transport jet engines to permit precise and rapid measurement of shock-wave location. The output of system will eventually be used to control shock-wave position and thereby make the best use of engine efficiency and increase operational safety. The small insert photo shows the entire nucleonic system before installation; the black cylinders are the krypton sources.

effects. A 12-pound, battery-operated electronic unit registers the two backscattered radiation intensities. A simple ratio of the response from these two energies relative to that from the aggregate gives a practical calibration curve which an experienced gauge operator can interpret. Heretofore, the strength of concrete could be measured directly only after pouring, hardening, and curing. Then, it is normally too late (and too expensive) to rectify mistakes, particularly in highway construction.

Oil Slick Identification

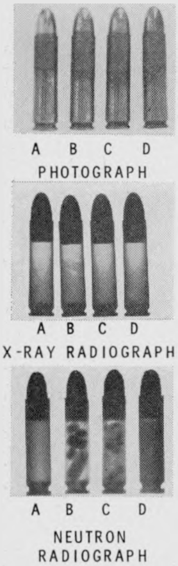
The pollution of coastal and tidal waterways and harbors by oil that has been released from ships is a serious problem with respect to preservation of many natural resources. A study by Gulf Energy and Environmental Systems, Inc. (San Diego, Calif.) of analytical techniques for identifying the origin of oil slicks has demonstrated that radioisotopic methods (neutron activation analysis) offer a feasible means of identification. The method is based upon the observation that different oils contain different amounts of identifiable trace elements. A processed sample of the oil in a given oil slick can be compared with collected samples of oils at the suspected pollution sources, such as oil tankers in an affected harbor. A match between the oil slick composition and that of oil samples from a particular tanker may provide sufficient corroborative evidence for conviction and imposition of penalties on a tanker that is the source of the oil slick.

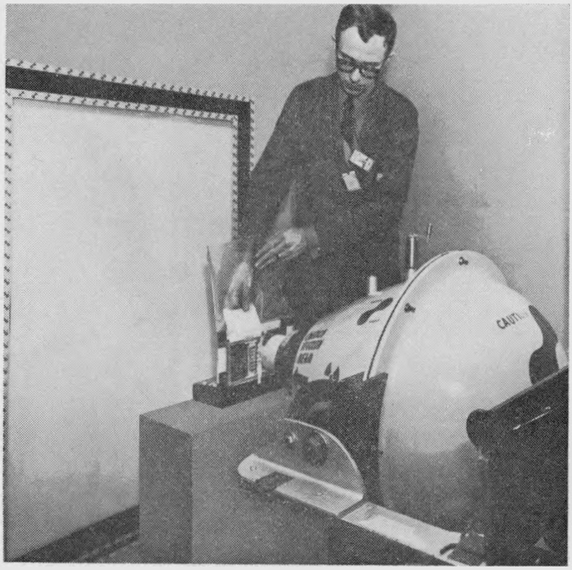
Auto Exhaust Monitor

Efforts to measure and control air pollution from automobile exhausts presently are hampered by lack of a simple, economic instrument for monitoring the three principal pollutants—carbon monoxide, nitrogen oxides, and hydrocarbons. During 1970, technical feasibility of a radioisotope-based system for accomplishing these purposes was demonstrated by Panametrics, Inc. (Waltham, Mass.) under AEC contract. The concept involves measuring the amount of krypton-85 given off as the exhaust gases pass over a kryptonate sensor. Practical feasibility of developing an effective and economic instrument suitable for field use is being determined. If feasibility is established, a demonstration instrument will be constructed and loaned for field evaluation purposes to Federal and local regulatory groups having responsibility for monitoring and controlling auto exhaust emissions.

Californium-252

It takes approximately a year to transmute a given amount of plutonium-242 (through 10 neutron captures interspersed with four beta decays) to a much smaller amount of californium-252 (Cf^{252}) in the





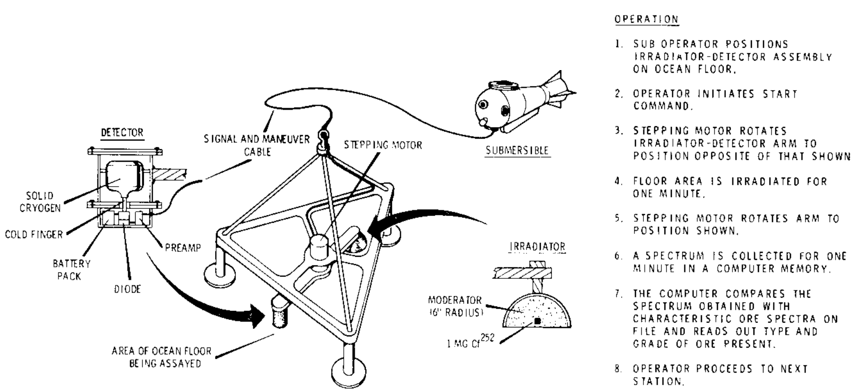
A Portable Neutron Radiography Unit developed at the AEC's Pacific Northwest Laboratory (PNL) has added to the broad number of uses to which the manmade radioisotope, californium-252, lends itself. At *right*, John Cason, a research scientist in PNL's Nondestructive Testing Department, prepares a sample for exposure in front of the "atomic" camera which he developed. The camera is able to "see" into metals, spot narcotics in metal containers or in body cavities, and look into bombs and ammunition for boobytraps. The camera uses a radioactive source, californium-252, to generate the neutrons that take the "picture." At *left top* is a regular photograph of four rounds of 30-caliber ammunition. Round *A* is empty, round *B* contains a quantity of LSD pills and capsules, round *C* contains marijuana leaves, and round *D* is a standard round of ammunition with gunpowder inside the case. The radiograph (at *center*) was made with X-rays and reveals very little about the contents of the cartridges because passage of the X-rays through the samples is affected very little by the light, organic, narcotic materials. However, the same materials strongly affect neutrons, so the neutron radiographs (at *bottom*) from the atomic camera "see" the empty round *A*, the narcotics in rounds *B* and *C*, and the gunpowder in round *D*. The 100-pound camera is relatively portable. Previously neutrons for radiography were obtained by exposure to atomic reactors or large neutron generators, both of which require heavy shielding and are nonportable.

production reactors at the Savannah River Plant; additional time is needed to refine the Cf^{252} out of the other end-products (plutonium, americium, and curium) in the Transuranium Processing Plant at Oak Ridge National Laboratory. The results of the production campaigns undertaken by the AEC in the 1968–69 period are now providing increasing quantities of californium-252 available for developmental studies. Its intense neutron yield, low gamma emission rate, and relatively long half-life (2.5 years) makes Cf^{252} valuable for many applications[3] in research, medicine, and industry (see table 3 in Chapter 3).

Portable Atomic Camera

Testing and developmental work is continuing at Pacific Northwest Laboratory on a portable camera developed to detect flaws in metal or quantities of drugs concealed in metal or other containers.

[3] See p. 53, "Annual Report to Congress for 1969."



An Undersea Probe to Detect Valuable Minerals on the ocean floor has been successfully demonstrated by the AEC's Pacific Northwest Laboratory. Using californium-252 as a neutron source, the device can locate 20 to 30 elements in quantities as low as 1 ounce per ton. In the initial test of the probe, 200-pound mineral samples containing gold, silver, copper, and manganese were placed on the bottom of the ocean at Sequim Bay, Wash. The four elements were detected and measured with a probe containing 0.2 milligram—about one one-hundred-thousandth of an ounce—of the manmade californum-252 and an extremely sensitive gamma-ray detector. Californium-252 emits neutrons which are absorbed by the minerals being measured. The minerals then give off energy in the form of gamma rays which are picked up by the detector. The amount of an element in a mineral is proportional to the number of gamma rays emitted. The californium source is in a sealed stainless steel cylinder approximately one-half inch in diameter and 3 inches long which is located at the end of the probe. The device is designed to operate from either a surface ship or submarine as shown in the diagram.

The 100-pound neutron or "atomic" camera uses 268 micrograms of the radioisotope californium-252 to generate the neutrons which penetrate opaque materials in a radiographic technique. Californium-252 has a higher neutron emission rate than other available isotope neutron sources.

The device has demonstrated potential as a tool for customs or enforcement officers and for other applications including safety checks of radioactive heat sources and reactor components such as fuel elements, control rods, and shielding materials for quality of welding and structural integrity.

The use of californium allows the neutron camera to be set up whereever needed. Current neutron radiography methods used industrially for nondestructive testing require neutrons obtained from a nonportable accelerator or nuclear reactor.

Because drugs and narcotics are made of light atoms, they are not easily detected by normal X-ray techniques, but are readily observed by neutron radiography. Metal weaknesses or other foreign substances are also readily "seen."

In the radiographic technique, some neutrons beamed toward the test specimen pass through. Others are partially or completely stopped by the more absorbent parts of the subject and cast a shadow on photographic film. Variations in shadow pattern form a neutron radiograph similar to a doctor's X-ray showing embedded foreign matter, nonuniformities in density, etc. Two other forms of radiography, X-ray and gamma, use ionizing radiation.

An undersea probe to detect valuable minerals on the ocean floor has also been successfully demonstrated by Pacific Northwest Laboratory.

HEART ASSIST PROGRAM

Experience with heart transplants over the past several years has stimulated interest in the feasibility of a fully implantable artificial heart. Ideally, the power source for such a device should be completely self-contained so that the artificial heart recipient is free to lead a near-normal life independent of any need to "recharge" batteries or otherwise rely on outside sources of power. Radioisotope heat sources appear to meet all such requirements. The AEC has sponsored studies over several years looking toward ultimate perfection of a radioisotope-powered, fully implantable artificial heart device. The AEC is also sponsoring development of a radioisotope powered cardiac pacemaker.

Artificial Heart Fuel Studies

Plutonium-238 has been selected as the power source fuel for artificial heart devices. In work at Los Alamos Scientific Laboratory, the extraneous radiation from plutonium-238 has been reduced sufficiently by electrorefining the feed material and oxygen-16 enriching the desired plutonium dioxide fuel form. Promethium-147 was eliminated by the AEC from further consideration after it was concluded that extraneous radiation could not be reduced sufficiently to make it acceptable for clinical applications.

Heat Source Subsystem

To evaluate what effect might be expected from the use of radioisotope heat sources in artificial heat devices, a radioisotope heat source subsystem was fabricated by Hittman Associates, Columbia, Md., during the year for measuring the radiation produced by such a device. The radioisotopic material was suitably encapsulated and insulated as it would be in actual use. Measurements also were made of the heat output, heat losses, insulation efficiency, and effects of temperature resulting from rapid changes from low to high heat output and reverse. Electrical heat was used at first and then an actual plutonium-238 heat source. These tests serve to establish the safety and efficiency criteria for implantable radioisotope heat sources.

Effect of Heat Source Implanted in Dog

An experiment [4] to determine the physiological effect of implanted isotopic heat sources on animals was completed in 1970 by the National Heart and Lung Institute (NHLI) (Bethesda, Md.) with the sacrifice of the second dog to have received a plutonium-238 heat source implant. This dog carried the 24-watt source over a period of 27 months; the first dog had carried an implanted source for 26 months. Post-mortem examination of the dogs revealed no clinical effects. In both cases the plutonium-238 heat sources were provided to NHLI by the AEC.

Radioisotope-Powered Cardiac Pacemaker

A radioisotope-powered cardiac pacemaker is being developed for the AEC by Nuclear Materials and Equipment Corp. (NUMEC),

[4] See p. 182, "Annual Report to Congress for 1969."

Apollo, Pa., a subsidiary of the Atlantic Richfield Co. A nuclear-powered pacemaker, with an operating lifetime of at least 10 years, would eliminate the need for relatively frequent surgical replacement of present chemical battery-powered pacemakers with their 2- to 3-year life. The units provide the cardiac muscle stimulation required in the correction of "heart block", a relatively common human affliction.

Since May 1969, eight of the nuclear-powered pacemakers have been surgically implanted in dogs for testing at the National Heart and Lung Institute, National Institutes of Health, Bethesda, Md. During 1970, six of the units failed; the others continued to operate satisfactorily. In three cases, the failures were limited to the pacer's electronic circuitry as a result of defective components in the circuits. In two cases, the nuclear battery failed because of repeated mechanical shocks received from the dogs' activities in their pens. Although the units normally would not receive rough treatment in humans, conservative reliability testing demands survival of the units in dogs. The sixth unit failed in both the electronic circuit and the nuclear power supply. The power-supply failures were caused by broken wires in the thermopiles, and there was neither damage to the plutonium-238-fueled heat source nor any release of radioactivity.

The failures were not fatal to the dogs because the animals had healthy hearts and were not dependent upon the pacemakers. The cause of the failures were identified and corrective measures taken to eliminate similar failures in future units.

NUMEC is presently establishing a pilot production line to demonstrate the feasibility of manufacturing radioisotope-powered pacemakers in quantity. The pacemakers fabricated in this pilot production line will be used for further reliability tests in the laboratory and in dogs. When sufficient reliability has been demonstrated, a number of units will be clinically tested in human patients.

Chapter 9

PEACEFUL NUCLEAR EXPLOSIVES

The AEC, through its peaceful nuclear explosives (Plowshare) program, is fostering the development of a technology that holds promise for improving natural resources utilization and for large-scale civil works projects.

THE PLOWSHARE PROGRAM

The AEC's Plowshare program focused its 1970 effort on research aimed toward the development of a peaceful nuclear explosion technology to improve natural resources utilization, especially stimulation of production from natural gas fields and increase the Nation's gas reserves. A field experiment, Flask, was conducted in May at the Nevada Test Site to test design improvements in a nuclear explosive for excavation applications. AEC laboratories performed research on the explosion effects of both underground engineering and excavation applications and, at yearend, an AEC laboratory proposal to use an underground nuclear explosion for scientific research was under study.

UNDERGROUND ENGINEERING

During 1970, the underground engineering portion of the Plowshare program concentrated on hydrocarbon applications, such as increasing natural gas production and storage facilities, because of the urgent national need to develop additional energy supplies, especially from clean fuels. Although no experimental detonations in gas stimulation were conducted in 1970, the program effort was concentrated on obtaining data and interpreting results obtained from earlier experiments conducted in natural gas fields. The AEC is cooperating with industry in a study to examine the feasibility of using nuclear explosions to tap geothermal energy for use in generating electric power.

Design effort on explosives with improved characteristics for underground engineering hydrocarbon applications was begun in 1970.

Explosive Design

To meet engineering and environmental considerations peculiar to hydrocarbon applications, work was begun to develop an explosive with the following characteristics: (*a*) Small diameter; (*b*) minimum tritium production; (*c*) ability to withstand environmental conditions of high pressure and temperature in deep drill holes; (*d*) minimum use of special nuclear materials; and (*e*) reinforced to survive ground shock and electromagnetic signals should two or more explosives be fired sequentially. Firing of two or more explosives emplaced in horizontal or vertical arrays for a given application is expected to produce more fracturing effects and reduce or diffuse ground motion that could result from a single, equivalent-yield explosion. A field test of an explosive with some of these characteristics is planned for early 1971.

Natural Gas Stimulation

The generally acknowledged energy crisis has brought about increased interest in the use of nuclear explosions to recover and make use of natural resources which were not previously economically recoverable by conventional means. Research has concentrated on using a nuclear explosion to increase or "stimulate" natural gas production from tight gas-bearing geologic formations. Two experiments have been conducted: (a) Project Gasbuggy [1] with El Paso Natural Gas Co., in 1967; and (*b*) Project Rulison [2] with Austral Oil Co., and CER Geonuclear Corp., in 1969. Production testing and gas sampling of the Gasbuggy chimney provided substantial useful information. Evaluation of Rulison data should provide additional indications of the potential usefulness of this new technology.

Project Gasbuggy

Continued testing during 1970 showed no radioactivity in the wells near the Gasbuggy experiment. Gasbuggy was conducted in the San Juan Basin near Farmington, N. Mex., on December 10, 1967. The 29-kiloton (kt.) detonation created a chimney of broken rock about

[1] See pp. 199–200, "Annual Report to Congress for 1967," p. 200, "Annual Report to Congress for 1968" and p. 198, "Annual Report to Congress for 1969."

[2] See p. 196, "Annual Report to Congress for 1969."

333 feet high and a void volume of about 2 million cubic feet, 3,900 feet below the surface. It was the first Government-industry Plowshare experiment. Production tests of the Gasbuggy chimney well so far have resulted in a cumulative production of 280 million cubic feet of gas, all of which was burned at the Wellhead. If the well were in production over a 20-year period, it might be estimated to produce nearly 900 million cubic feet of gas which is at least five times better than the average production of a conventional well in the same area. During 1970, field activity on Gasbuggy consisted of periodic monitoring for radioactivity in feeder lines from nearby wells. No radioactivity attributable to Gasbuggy was found. The reentry wells at Gasbuggy remained sealed to allow pressure to build up before additional production testing in 1971.

Project Rulison

Radiochemical analysis of natural gas samples taken in August 1970 from the Rulison well near Grand Valley, Colo., have shown that the tritium in the gas is lower than had been anticipated and only one-fifth that found in the Gasbuggy experiment. Rulison was the second Government-industry gas well stimulation experiment; the 40-kt. detonation occurred 8,431 feet below the surface on September 10, 1969.

The technical objectives of the Rulison experiment are to: (*a*) Measure changes in gas production rates in the Mesa Verde formation; (*b*) measure flow capacity; (*c*) determine gas quality including amount and distribution of radioactivity in the gas; (*d*) evaluate techniques for further reducing the amount of radioactivity in the gas; (*e*) estimate the extent of the chimney and fractures through production testing; and (*f*) evaluate seismic effects.

Court Actions. Before the detonation and again between detonation and scheduled postdetonation testing, court injunctions to halt the project were sought by parties opposed to it on environmental and safety grounds.

The AEC's testimony in connection with these court actions included descriptions of the predicted effects of both the nuclear detonation and the later controlled burning of natural gas containing a fraction of the radioactivity from the explosion. It also included descriptions of the precautions which would be taken to assure the safety of people and protection of the environment.

The U.S. District Court for the District of Colorado, in its decision, concluded that the plaintiffs had not presented adequate evidence to support their requested actions and that the evidence presented showed that AEC rules and regulations and project actions and plans for the post detonation phase constituted a "reasonable exercise of its statutory authority to conduct research in the utilization of atomic energy

Low Tritium Radiation Levels in the air around the Project Rulison site near Grand Valley, Colo., during the natural gas calibration flaring operation October 4–7, 1970, ranged from normal background level to about one four-hundredth of the established Radiation Concentration Guide (RCG). No radioactivity above background has been found in streams and drinking water in the area. Sufficient data have been obtained on the amount and dispersion of radioactivity released in water vapor by the flaring (burning), shown *above*, during different weather conditions to insure that the planned production testing of the well can be conducted safely. Production testing began on October 26. The production test flaring is being conducted to determine the effective chimney and fracture volume, the long-term production characteristics of the gas reservoir, and the production capability of the well. Starting October 26, the well was flared for 9 days at a rate varying from 11 to 17 million cubic feet per day, shut down for 27 days for pressure buildup, flared for 20 days at a rate of 5 million cubic feet per day, and then shut down for approximately 40 days with plans to start the next flow test about February 1, 1971. At yearend, the quality of the gas was improving and the radioactivity in the gas decreasing as fresh gas flowed into the well from the surrounding fractured rock. The natural gas is from gas-bearing rock fractured by a 40-kiloton nuclear explosive detonated about 8,400 feet below the surface of the site on September 10, 1969. Project Rulison was the second Government-industry experiment to determine the feasibility of stimulating production from a low permeability gas-bearing formation using a nuclear detonation to fracture the rock.

while providing for the protection of the health and safety of the public."

Accordingly, these injunction requests were denied by the Colorado court and, in the case of the denial of an injunction to stop the detonation, plaintiffs' efforts to have the district court decision reversed by the U.S. Court of Appeals for the Tenth Circuit and by the U.S. Supreme Court were unsuccessful.

Encouraging Results. Data evaluations indicate that the 40-kt. explosive performed as expected. Drilling to reenter the fractured zone began in April and was completed in July. Difficulties with plugging of the production tubing delayed well testing until October. Preliminary data on gas quantity and production rates are encouraging. The long-term production tests should be completed by late spring of 1971 and will provide more conclusive data on the actual effects of the nuclear stimulation.

Other Gas Stimulation Proposals

Several potential gas stimulation experiments are currently under joint Government-industry project definition study: WASP, a joint venture undertaking headed by Oil & Gas Futures, Inc. of Midland, Tex.; and Wagon Wheel, with El Paso Natural Gas Co. Tentative sites for both of these are located in the Green River Basin near Pinedale, Wyo. The most recently proposed undertaking being studied is named Rio Blanco and would be located in western Colorado. It is sponsored by CER Geonuclear Corp. as an experiment proposed instead of Dragon Trail.[3] A project definition study agreement was signed on December 18, 1970. These potential experiments would provide additional information [4] for use in determining the economic and technical feasibility of producing natural gas by nuclear stimulation from tight gas-bearing formations at great depths in an environment of high temperature and pressure. The Rio Blanco proposed involves the potential use of two or more explosives in the same hole.

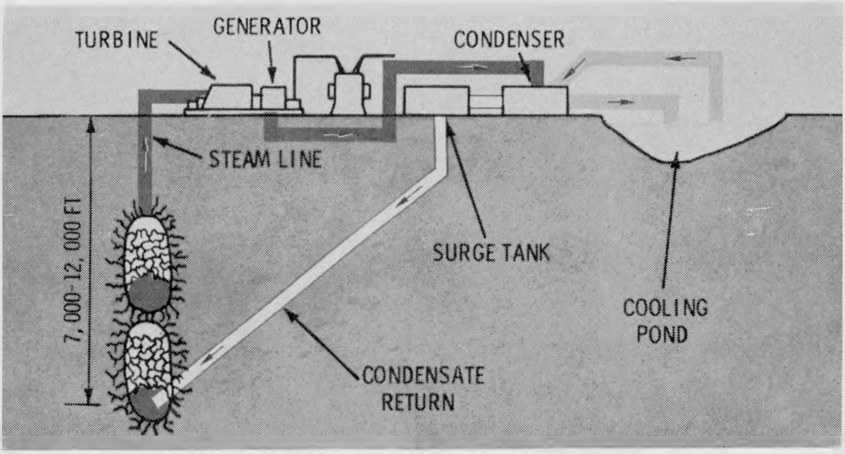
Other Underground Engineering Applications

Underground engineering technology is also being considered for use in recovery of oil from oil shale, mineral recovery, underground

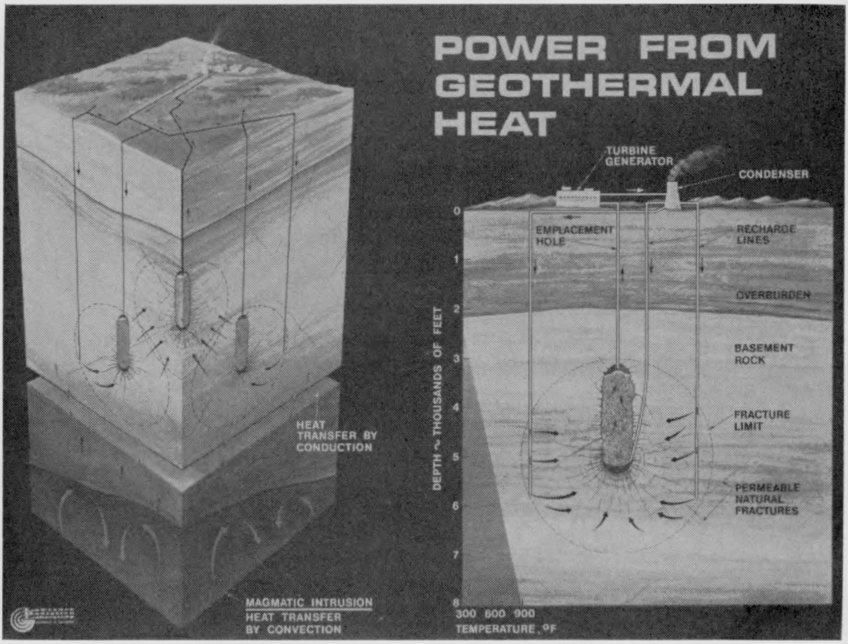
---

[3] See p. 200, "Annual Report to Congress for 1969."

[4] Data and reports on Projects Gasbuggy and Rulison are maintained by the AEC and project participants in public files at these locations: Federal Center, Denver, Colo.; Petroleum Research Center, Bartlesville, Okla.; and Nevada Southern University, Las Vegas, Nev.



The Possibility of Using Nuclear Explosives to Create Steam-Generating Cavities deep underground is being investigated. The concept involves the creation of cavities in dry, underground geothermal formations; water, channeled into the cavity from the earth's surface would be turned into steam by the naturally hot surrounding rock; piped to the surface, the steam would be used for the generation of electricity; the steam would then be condensed to water and recycled to the cavity. The closed-circuit basic concept is shown in the *above* Pacific Northwest Laboratory (PNL) drawing. Dry, hot rock formations exist under portions of 10 Western States ("wet" formations are the source of geysers); the dry geothermal process is shown at *left below* in the Lawrence Radiation Laboratory-Livermore drawing. The joint PNL study is under the sponsorship of the American Oil Shale Corp. (Salt Lake City, Utah), Westinghouse Electric Corp. (Pittsburgh, Pa.), Utah Power & Light Corp., and the AEC.



storage, waste management, water management, and use of geothermal energy. The geothermal energy area is the latest of these concepts to be studied. A cooperative study is currently being conducted to investigate the economic and technical feasibility of using nuclear explosions to break rock in dry underground geothermal formations where introduction of water could produce steam for the generation of electric power. During 1970, there was also active interest by several companies in the use of Plowshare technology for gas storage projects and mineral recovery applications.

NUCLEAR EXCAVATION

The potential of nuclear explosions for large excavation projects covers a range of possible uses: Navigable waterways, dams, storage reservoirs, harbors, and for highway or railroad passes through mountainous terrain.

In May, an explosive device development test named Flask at the Nevada Test Site successfully extended the design of excavation explosives being developed to a yield significantly greater than that used in the 35-kt. Schooner experiment.[5] The success of this test provides a proven explosive design in the 100-kt. range with fission product radioactivity four times less than the pre-Flask design. Analysis of data from past cratering experiments continued during the year.

Panama Canal Study

Considerable information on the feasibility of nuclear excavation, including operations and safety was provided the Atlantic-Pacific Interoceanic Canal Study Commission for consideration in preparing its report to the President on the feasibility of constructing a sea-level canal in the American isthmian region. The Canal Study Commission transmitted its final report on December 1, 1970, and stated: ". . . although we are confident that someday nuclear explosions will be used in a wide variety of massive earth-moving projects, no current decision on U.S. canal policy should be made in the expectation that nuclear excavation technology will be available for canal construction. . . ." It was recommended that ". . . the U.S. pursue development of the nuclear excavation technology, but not postpone Isthmian Canal policy decisions because of the possible establishment of feasibility of nuclear excavation at some later date."

On July 7, AEC Chairman Seaborg had informed Robert B.

[5] See p. 198, "Annual Report to Congress for 1968."

Anderson, Chairman of the Canal Study Commission, that the AEC had not been able to do all of the experiments required to make a determination of the feasibility of using nuclear explosions for the excavation of canals under study by the Canal Study Commission and that, consequently, any decision in the near future to construct a sea-level canal would have to be made without reliance on nuclear excavation.

PROGRAM DEVELOPMENTS

During 1970, the AEC continued to provide industry and the public with information about the potential benefits of the use of nuclear explosives for peaceful purposes. During January, the AEC cooperated with the American Nuclear Society in holding a 3-day, international topical meeting at Las Vegas, Nev., on "Engineering with Nuclear Explosives." (The last general public review of Plowshare technology had been the Third Plowshare Symposium in 1964.[6]) Over 600 registrants, including representatives from 16 foreign nations attended selected sessions at which 104 U.S. papers and eight foreign papers were given.[7] (See also "Peaceful Nuclear Explosions" item in Chapter 10—International Affairs and Cooperation.)

---

[6] See pp. 175–176, "Annual Report to Congress for 1964."

[7] Proceedings in 2-volume set entitled "Engineering with Nuclear Explosions," available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151. Price $6 a set.

Chapter 10

INTERNATIONAL AFFAIRS AND COOPERATION

The United States continued its leadership in developing peaceful uses of nuclear energy. Cooperation with other nations and international organizations is accomplished through the exchange of information, supply of materials, and training of personnel. There was continuing close cooperation with the International Atomic Energy Agency (IAEA) during the year.

INTERNATIONAL COOPERATION

On March 5, 1970, the United States and the U.S.S.R. deposited their instruments of ratification of the Treaty on the Non-Proliferation of Nuclear Weapons. This action, along with the deposit of instruments of ratification by the United Kingdom and 45 nonnuclear weapon states, brought the treaty into force. The treaty, among other things, assigns to the IAEA important safeguards responsibilities. The United States has been actively participating on the special committee set up by the IAEA's Board of Governors to develop procedures for carrying out the IAEA's responsibilities under Article III of the treaty which requires international safeguards on the peaceful nuclear activities of nonnuclear weapon states parties to the treaty (see "Nuclear Materials Safeguards" in Chapter 4).

During the year, 14 new toll enrichment contracts were executed under Agreements for Cooperation with other countries. Future revenues from these contracts are estimated to be about $295 million. Toll enrichment contracts coming into force since 1969 will result in long-term revenues to the AEC of approximately $690 million. Toll enrichment, under which the customer's natural uranium is enriched in the uranium-235 (fissionable) isotope is the normal method of supplying U.S. enriched uranium for power reactors abroad.

COOPERATIVE ARRANGEMENTS

At the end of 1970, 34 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). These agreements cover cooperation in the development of the peaceful uses of atomic energy and involve the transfer of special nuclear material primarily for specific reactor projects, as well as the exchange of information; they also provide for safeguards on U.S.-supplied nuclear material. Under a number of the agreements, cooperation extends to the development of atomic energy in the commercial power field in addition to research.

During 1970, the United States concluded a 30-year research and power agreement with Finland and an amendment to the current agreement with Sweden. In each case, the major purpose was to pro-

When France's President Georges Pompidou visited the Stanford Linear Accelerator Center (SLAC) near Palo Alto, Calif., in February, the number of accompanying news media representatives was almost larger than the official party. In the photo *above*, President Pompidou (leaning on rail) is being briefed by Dr. Wolfgang K. H. Panofsky, Director of SLAC, as he studies a portion of the 2-mile-long electron beam tube (below *arrow*) from the gallery. The visit to the linear accelerator center, the only AEC facility to be visited by President Pompidou, followed a visit to the National Aeronautics and Space Administration facilities at Cape Kennedy.

vide for the supply of enriched uranium fuel necessary for the long-term requirements of power reactors in the respective national atomic energy programs. Also, amendments to the agreements with Colombia, Indonesia, Venezuela, Norway, and the United Kingdom were brought into force in 1970. The first three of these extended and updated expiring agreements while the last two provided new authorization with respect to the transfer of special nuclear material; in the case of Norway for the transfer of uranium-233 and in the case of the United Kingdom for the conversion or fabrication and return to the United States of special nuclear material.

The Commission met with the Japanese AEC on March 24 and 25 for policy level discussions. A similar meeting was held with the Board of Directors of Atomic Energy of Canada, Ltd., on May 25–26.

International Atomic Energy Agency

The United States continued its strong support of the International Atomic Energy Agency (IAEA) through cooperation in all of the IAEA's activities, including international safeguards, and through contributions to both its assessed and voluntary budgets, the latter of which supports technical assistance for developing countries.

The AEC organized U.S. participation in 15 conferences sponsored by the IAEA. Principal among these was a symposium on "Environmental Aspects of Nuclear Power Stations" held August 10–14 at United Nations Headquarters in New York City. More than 500 persons from 26 nations and 9 international organizations attended. U.S. delegates presented 30 papers.

IAEA-sponsored training courses were held at Cornell University (Ithaca, N.Y.) in radioisotope applications in animal sciences, and at the Puerto Rico Nuclear Center in dosimetry in radiotherapy. On a study tour sponsored by the IAEA, 18 scientists from 16 Asian and Latin American countries visited U.S. organizations using a wide variety of radioisotopes and radiation techniques in industry.

The 103-member IAEA held its 14th General Conference in September. The Agency's budget for 1971, in the amount of $13 million for the assessed and a $2.5 million target for the voluntary budget, was approved, as was the program for 1971–76. Additionally, the Conference approved, for ratification by member Governments, an amendment to article VI of the IAEA's statute which would modify the categories from which members of the Board of Governors will be selected and increase the board's membership from the present 25 to 34. The amendment will require ratification by two-thirds of the members before becoming effective.

Under the Non-Proliferation Treaty, which entered into force on March 5, 1970, the IAEA has the responsibility for verifying that nuclear energy is not diverted from peaceful uses to use in nuclear weapons or other nuclear explosive devices in nonnuclear weapon countries party to the treaty.

U.S. policy provides for the transfer to the IAEA of the safeguards responsibilities included in various bilateral agreements for cooperation in the civil uses of atomic energy between the United States and other countries through the negotiation of trilateral agreements among the United States, the IAEA, and the country involved. A total of 21 trilateral agreements are in effect, and others are being negotiated (see also "Nuclear Materials Safeguards" section in Chapter 4).

European Atomic Energy Community (Euratom)

In the 10 years of its existence, the U.S.-Euratom [1] research and development program for the advancement of light water reactor technology, which terminated in 1969, played an important role in the growth of nuclear power development in Europe and was a significant factor in the nearly universal acceptance of U.S.-type light water (boiling water or pressurized water) reactors for power applications. During 1970, enrichment services and direct sales of special nuclear materials worth $47.7 million, approximately 16 percent of the total U.S. nuclear sales to foreign customers, were arranged through the Euratom Supply Agency on behalf of nuclear power and research programs in the European community. U.S. cooperation with Euratom has continued primarily in the furnishing of special nuclear material, together with exchanges of technical information. The U.S.-Euratom Joint Technical Working Group met twice during the year to discuss safeguards matters. Demonstrations of safeguards techniques were held both in Europe and in the United States.

European Nuclear Energy Agency

During 1970, the AEC continued to cooperate with the European Nuclear Energy Agency (ENEA) through exchanges of information on a broad range of peaceful uses of atomic energy. The AEC made available to the ENEA those standards which have been adopted and developed by the U.S. regarding safety in a particle accelerator environment. The AEC worked closely with the Health and Safety Committee of ENEA in developing a guide for the safety analysis

---

[1] The European Atomic Energy Community (Euratom) is composed of Belgium, France, the Federal Republic of Germany, Italy, Luxembourg, and The Netherlands.

and control of products containing radionuclides which are available to the general public. In addition, the AEC agreed to participate in a food irradiation program being organized by the ENEA and IAEA.

Inter-American Nuclear Energy Commission

During 1970, the Inter-American Nuclear Energy Commission (IANEC)—composed of 13 Western Hemisphere countries, including the United States—carried out a variety of activities. These activities included participation in study groups, support of specialists to participate in international conferences, equipment grants, and direct technical assistance to member states, and sponsorship of training courses.

Technical Exchange Arrangements

Technical exchange arrangements constitute an important means by which technical information in the atomic energy field is shared mutually with atomic energy organizations in other countries. Throughout 1970, technical collaboration with 15 countries and three international organizations was continued, notably with Canada on the production technology for manufacturing heavy water, with the United Kingdom, Germany, and Japan on fast breeder reactors, and with Australia, India, and Israel on evaluated nuclear data. New technical exchange arrangements were initiated with: (*a*) Organization For Industrial Research of The Netherlands to exchange information on facilities used for testing components for sodium-cooled fast breeder reactor powerplants; and (*b*) the Gesellschaft für Kernforschung (GFK) of Germany to exchange data on fast reactor irradiation of nuclear fuel assemblies. During 1970, collaboration with the Dragon Project on high temperature gas-cooled reactors was extended for an additional 3 years through March 31, 1973.

Laboratory-to-Laboratory Arrangements

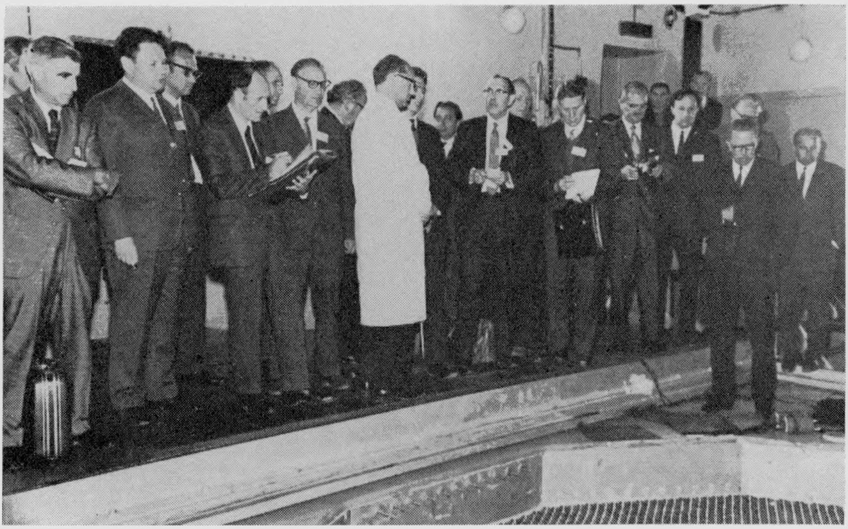
A new laboratory-to-laboratory cooperative program was initiated in 1970 between Argonne National Laboratory and the Institute of Nuclear Energy Research in Taiwan. During 1970, scientific cooperation continued between: Oak Ridge National Laboratory and the Pakistan Institute of Nuclear Science and Technology; Argonne National Laboratory and the Salazar Nuclear Energy Center in Mexico and the

Tsing Hua University in Taiwan; and Brookhaven National Laboratory and the Democritus Nuclear Research Center in Greece.

Cooperation with Soviet Bloc

The Memorandum on Cooperation in the Peaceful Uses of Atomic Energy, providing for personnel and unclassified information exchanges between the AEC and U.S.S.R. State Committee on the Utilization of Atomic Energy (SCAE), was renewed for another 2 years. The Memorandum, an annex to the overall U.S.-U.S.S.R. Exchange Agreement, was signed on February 10, 1970, in Washington. On November 30, the AEC and the SCAE concluded, under the Memorandum, a protocol covering joint projects in the field of high-energy physics.

Under the terms of the Memorandum, the first Soviet-American col-



Ten U.S. Reactor Specialists, representing industry and the AEC, toured nuclear facilities in the U.S.S.R. for 2 weeks in June 1970. The visit was in reciprocity for the tour of U.S. facilities by 10 Soviets in November 1969. The nuclear reactor facilities that the U.S. delegation toured included the Institute of Physics and Power Engineering at Obninsk; the Scientific Research Institute of the Atomic Energy Reactors at Melekess; the dual-purpose Atomic Electric Power Station (power generation and desalting) at Shevchenko; the Beloyarsk Nuclear Superheat Power Station as well as the large Fast Breeder Power Reactor under construction at Beloyarsk; the I. V. Kurchatov Atomic Energy Institute, Moscow; the Novovoronezh Nuclear Power Station at Novovoronezh and the Headquarters of the State Committee on Atomic Energy in Moscow. Photo *above* shows the note- and picture-taking U.S. group observing the Soviet's largest fast critical assembly (BFS–2) at Obninsk.

laborative experiment in the nuclear sciences is currently taking place. Five U.S. physicists are spending 6 months at the High Energy Physics Institute at Serpukhov in the Soviet Union, working with Soviet scientists from the Joint Institute for Nuclear Research in Dubna in the investigation of elementary particles. The Serpukhov Institute, located near Moscow, contains the world's highest energy accelerator (76 Bev.). A reciprocal opportunity will be afforded Soviet scientists at the 200-Bev. accelerator, now under construction at the National Accelerator Laboratory (NAL) at Batavia, Ill. Toward this end, two Soviet physicists attended a summer study seminar at NAL which should prove useful for the selection of a collaborative project for consideration as part of the experimental program of the 200-Bev. accelerator.

A 2-week visit by a team of turbulent heating specialists in the field of controlled thermonuclear research to laboratories in Moscow and Kharkov was the first of its kind under the Memorandum. Also in the field of controlled thermonuclear research, at the present time, a U.S. scientist is on a 6-month assignment at the Kharkov Physical Technical Institute.

A delegation of 10 U.S. nuclear reactor specialists toured laboratories and nuclear power installations in the U.S.S.R. for 2 weeks in June and July. This visit was in reciprocity for the tour of U.S. facilities made by Soviet reactor specialists in November 1969.

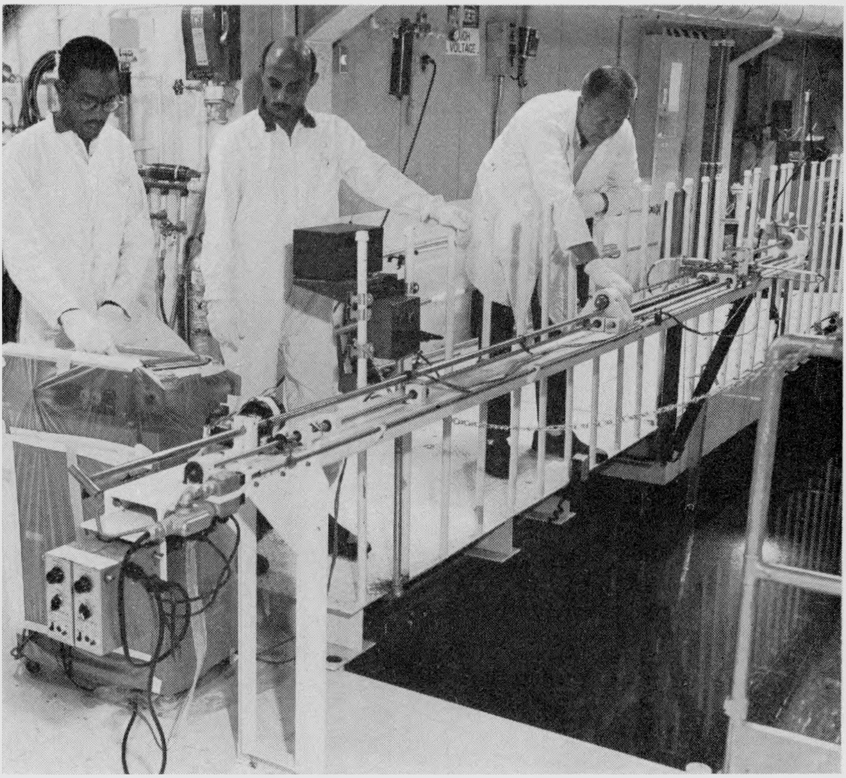
Scientific interchange with countries of Eastern Europe and with the U.S.S.R. in activities in addition to those under the Memorandum continues to increase.

Peaceful Nuclear Explosions

During 1970, there was a second set of bilateral meetings between representatives of the United States and the U.S.S.R. to discuss the peaceful nuclear explosions programs of the respective countries. During these talks, held in Moscow from February 12–17, the Soviets presented the results of nine peaceful nuclear explosion events that indicated they have an aggressive and advanced program in this field. The Soviets reaffirmed their declaration, made at the first set of "Plowshare" meetings in 1969, that the U.S.S.R. is prepared to offer a peaceful nuclear explosion service pursuant to article V of the Non-Proliferation Treaty (NPT).[2] In addition, there was an exchange of technical reports and films.

---

[2] Article V of the NPT states that ". . . Each party to the treaty undertakes to take . . . appropriate measures to ensure that . . . potential benefits from any peaceful applications of nuclear explosions will be made available to the nonnuclear weapon states party to the treaty . . . ."



Advanced Training Opportunities in the peaceful uses of atomic energy continue to be offered to foreign nationals at AEC facilities. In addition to the research assignments, primarily at the AEC's national laboratories, of trainees and scientists from the underdeveloped countries, opportunities for individual research programs and training in more sophisticated fields are provided by technical exchange arrangements. Areas of cooperation with countries having advanced nuclear programs have thus been broadened. In photo *above*, the use of a fuel rod profilometer at the Pacific Northwest Laboratory is being described by two Battelle-Northwest research scientists to Jagdish K. Bahl (*center*) Bhabha Atomic Research Center exchange scientist, Bombay, India. The profilometer is designed to measure and record irradiation-induced dimensional changes in fuel rods caused by fuel expansion and irradiation-induced fuel swelling, or other actions. Measurements made at Pacific Northwest Laboratory are reproducible to within 1/10,000th of an inch. This General Electric Co. profilometer is designed for underwater examination of irradiated fuel rods, a feature that eliminates the need to transfer the fuel rod back and forth between the reactor and a shielded hot cell. In addition to these types of personnel training assignments, short-term courses and individual training assignments continue to be offered by the Oak Ridge Associated Universities, Inc., Argonne National Laboratory, and the Puerto Rico Nuclear Center. Since 1955, foreign nationals participating in research at AEC facilities have numbered more than 7,100.

U.S. representatives also participated in an IAEA panel, the first on the effects of nuclear explosions for peaceful purposes, which was held in Vienna in March. Another IAEA panel in which the U.S. participated met during November to consider the matter of "international observation" under Article V of the NPT.

Nuclear Desalting

International interest and cooperative activities continued in connection with the potential use of dual-purpose nuclear power and desalting plants in the vicinity of the Gulf of California to supply electricity. The IAEA serves as a focal point for cooperation in this field.

Project Studies

A study by Oak Ridge National Laboratory (ORNL) on the potential of nuclear power-desalting plants as a means to agricultural and industrial development in the Middle East, was continued. The United States and Mexico consulted concerning possible further joint follow-on studies to a United States-Mexico-IAEA study report which concluded that it would be technically feasible to install nuclear power-desalting plants as a source of large amounts of fresh water and fresh water and power to the Southwestern U.S. and Northwestern Mexico. ORNL continued to provide technical advice in connection with India's interest in the potential application of nuclear-powered "energy centers."

COMMERCIAL ACTIVITIES

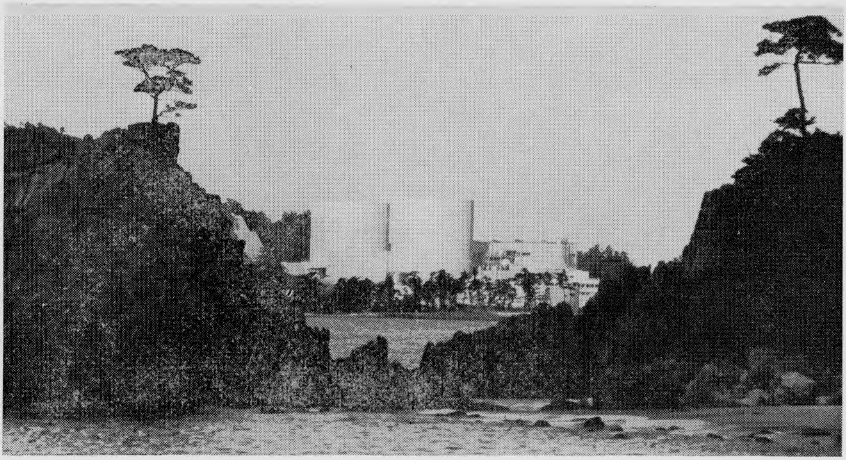
The success of U.S.-type light water reactors abroad continued in 1970.

In Japan, two major nuclear power projects reached the commercial operating stage, including the Japan Atomic Power Co. No. 2, a 331-Mwe. (megawatts of electricity) boiling water plant, which furnished nuclear generated electricity to Japan's Expo '70 world's fair. This was followed by the Kansai Electric Power Co. 340-Mwe. pressurized water reactor system, which also produced power for Expo '70. The Tokyo Electric Power Co., 460-Mwe. boiling water reactor is expected to begin commercial operation in early 1971. Japan's rising power needs and confidence in the light water reactor system

412-406—71——15

have led to a substantial acceleration in Japan's overall nuclear power program. This program, which includes both boiling and pressurized water reactors, is now expected to result in an installed capacity greater than 25,000 Mwe. by the end of 1980. It appears likely that it will become the largest nuclear power program outside of the United States using enriched fuels.

Nuclenor, Spain's second nuclear power project, a 440-Mwe. boiling water reactor, was completed at the end of 1970 and commercial



Kansai Electric Power Co.'s (KEPCO) Mihama No. 1 nuclear powerplant, a Westinghouse-built 340-Mwe. pressurized water unit shown *above*, went into commercial operation during 1970. This plant, located on the western side of the Tsuruga Peninsula at Niu, Honshu, Japan, transmitted power to the Expo-70 site. In photo *below*, a geologist is taking core samples in rice paddies in the valley at the site of Taiwan Power Co.'s 604-Mwe. boiling water plant which is to be built by General Electric at Chin Shan, Taiwan.

operation is expected to begin in early 1971. (Spain's first nuclear power station, a pressurized water reactor, began operation in 1968.) Sweden's first full-scale commercial plant, a 400-Mwe. boiling water reactor at Oskarshamm, also is expected to begin in early 1971.

During the year, foreign orders were placed with U.S. suppliers for 9 plants in 7 countries.

As of the end of the year, the Export-Import Bank of the United States had authorized approximately 18 projects involving American-supplied materials and equipment in nuclear plants abroad. These authorizations total approximately $600 million and involve a nuclear power capacity in excess of 6,000 megawatts. They provide financing for plants in France, Republic of China, Germany, Italy, Japan, Korea, and Spain. The financing also included provision for enriched fuel in most of these countries and also in Sweden.

India's Tarapur Nuclear Power Station, north of Bombay, was dedicated on January 19, 1970, by Prime Minister Indira Ghandi. Commissioner James T. Ramey represented the AEC at the dedication of the 400 Mwe. General Electric boiling water reactor plant which was built with U.S. financial assistance.

Materials Supplied Abroad and Services Provided

During 1970, 14 uranium enrichment contracts were executed under agreements for cooperation. 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 $295 million. For the 2 years during which toll enrichment services were made available, a total of 31 contracts were executed which will produce revenues of about $690 million over the life of the contracts. Export shipments to cooperating countries totaled approximately 3,521 kilograms (kgs.) of uranium-235 under toll enrichment agreements, 2,597 kgs. of uranium-235 under sale and lease agreements, and 45 kgs. of plutonium.

As of mid-1970, the AEC had distributed abroad through sale, lease, and deferred payment sales, special nuclear material and other materials to the approximate value of $437.6 million, resulting in revenues to the AEC of $355.1 million. The former figure is the value of materials distributed abroad under all types of financial transactions, including leases and deferred payment sale arrangements; the latter is the revenues realized from sales of material and enrichment services as well as interest received to date from leases and deferred payment sales. In 1970, the AEC negotiated the sale of 500 tons of heavy water valued at $29.4 million, for use as a coolant and/or moderator in power reactors in Canada.

The AEC continued to provide chemical processing services for fuel irradiated in Canadian and Japanese reactors. Ten shipments of spent fuel were received from these countries for reprocessing in the United States during 1970. The AEC also assisted the U.S. Coast Guard in clearing one additional port to handle shipments of radioactive materials, bringing to 49 the total number of ports cleared to date.

As in the past, the AEC continued to make available to foreign users for research purposes, small quantities of special material and small quantities of scarce isotopes.

Chapter 11

NUCLEAR EDUCATIONAL ACTIVITIES

The AEC's nuclear educational activities are, in general, directed toward: (*a*) Providing training opportunities to assure the manpower necessary to carry out the AEC's mission; (*b*) improving public understanding of nuclear energy; and (*c*) making available to science and industry the technical knowledge gained through its various programs.

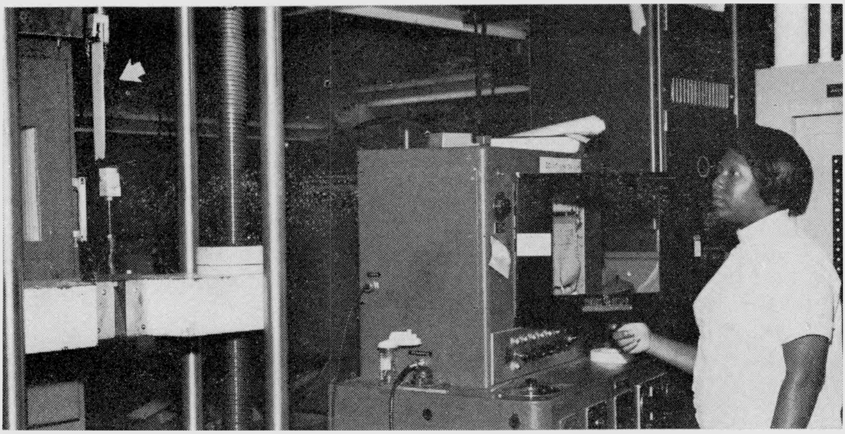
GENERAL TRAINING ACTIVITIES

The AEC's nuclear education and training programs seek to maintain a national capability to provide training in a variety of nuclear disciplines at all degree levels: associate, bachelor, master, and doctoral. Training and education programs are directed toward supplying engineers and scientists to meet current demands, as well as providing teachers of engineers, scientists, and technicians needed in the years ahead in academic, industrial, and Government positions.

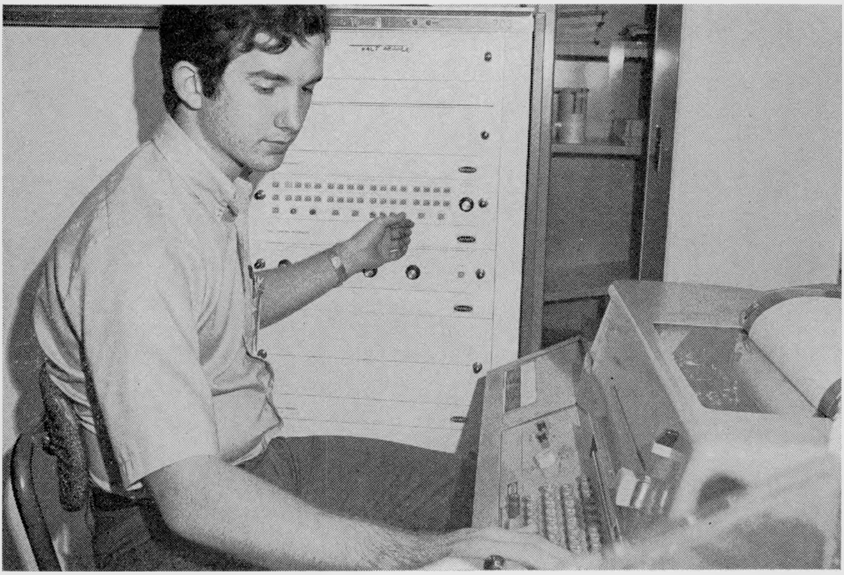
UNIVERSITY–AEC LABORATORY PROGRAMS

College and university facilities are strengthened to help meet national needs for nuclear education through access to AEC's extensive laboratory equipment. Through the University-AEC laboratory cooperative program, academic and AEC laboratory scientists are afforded excellent opportunities for the sharing of scientific experience, the exchange of ideas, the development of future educational activities, and the shared use of equipment which is often unique to AEC laboratory sites.

In 1970, over 2,605 faculty and 7,013 students from 799 institutions in 49 States participated in laboratory cooperative programs at AEC



Summer Student Training Programs at AEC laboratory sites provide opportunities for college students to participate in either original research projects on a current laboratory research program. Photo *above* shows an Arkansas Agricultural, Mechanical, and Normal College (Pine Bluff, Ark.) student operating a strain machine at Argonne National Laboratory to measure the force required to peel cellophane from epoxy (*arrow* at *left*). She was working on the laboratory project that led to the development of an artificial kidney (see illustrations in Chapter 12). At the Pacific Northwest Laboratory (PNL), a computer has been interfaced to a spectrophotometer and will be interfaced to several other instruments to analyze molecular spectra more quantitatively than possible by conventional means. Photo *below* shows a student from Nacogdoches, Tex., who was a NORCUS (the Northwest College and University Association for Science) summer trainee working at PNL. Through "debugging" and developing programs in the interfacing project, he became competent in the computer language Fortran and other machine language programing.



national laboratories and other specialized contractor-operated facilities.[1]

Summer Programs

At the AEC laboratory sites, college science faculty and students participate in original research projects or in the current laboratory research program. The opportunities thus provided benefit not only the faculty participant or the student and in his future employers' missions, but also the scientific staff and programs of the host laboratory and the AEC's research mission. In addition, faculty-student conferences, workshops, engineering practice schools and other formal educational activities continued. During the summer of 1970, these programs served 218 science faculty and 484 students at 16 AEC laboratory sites.

Used Nuclear Laboratory Equipment

The AEC moved into the second year of a program designed to build academic capabilities with used nuclear laboratory equipment no longer needed by the AEC. College science faculties locate such equipment through listings at the AEC sites and determine its usefulness for their nuclear educational programs. The AEC evaluates and selects proposals to insure the most effective use of the equipment in nuclear education. In 1970, 226 grants were made to 97 institutions in 34 States for equipment with original acquisition value averaging $3,850 per grant.

Puerto Rico Nuclear Center

The educational programs at the Puerto Rico Nuclear Center (PRNC) facilities at Rio Piedras and Mayaguez continued to strengthen the capabilities of Latin American countries for the peaceful uses of nuclear energy.

Through the PRNC, graduate-level courses in nuclear fields are available to students enrolled in programs of the University of Puerto Rico. Noncredit courses and programs are designed to train people in the use of radioactive materials in their fields of interest and to

---

[1] Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, 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 Laboratories, Savannah River Laboratory, Stanford Linear Accelerator Center, and University of Rochester Atomic Energy Research Project.

provide opportunities for visiting scientists to work on PRNC research projects.

In 1970, 191 students trained at PRNC; 40 students were from 14 Latin American countries and five were from four other countries around the world; the remainder were U.S. citizens.

COLLEGE AND UNIVERSITY PROGRAMS

Fellowships and Traineeships

Outstanding students in nuclear science and engineering and in radiation protection are awarded fellowships and traineeships for academic study needed for national purposes at the master and doctoral level. Recipients of these awards must be U.S. citizens and state their intention to teach or assume other positions in the atomic energy field.

In 1970, fellowships and traineeships had the following number of students enrolled on 41 campuses: nuclear science and engineering fellowships, 195; radiation science and protection fellowships, 58; laboratory graduate fellowships, 150; and nuclear engineering traineeships, 161. The laboratory graduate fellowships, representing 51 institutions, conducted their thesis research work at 15 AEC sites.

Reactor Sharing Program

University reactors are recognized as excellent educational and research facilities, especially useful for the conduct of graduate thesis projects in nuclear engineering and science. However, their support is beyond the means of smaller, and even many larger institutions. Through the reactor sharing program (started in 1969), many institutions now have access to a reactor at a neighboring university. Reactor sharing also encourages the exchange of ideas among present and future nuclear scientists. In 1970, the AEC supported reactor-sharing programs at seven universities where reactors are located: University of California at Los Angeles, Georgia Institute of Technology, Kansas State University, University of Michigan, State University of New York at Buffalo, Texas A. & M. University, and Washington State University.

Equipment Grants and Services

Grants for purchasing nuclear equipment for educational purposes totaling $148,227 were made during 1970 to 26 institutions of higher learning; this 15-year-old program was terminated in mid-1970.

Nuclear materials were furnished on loan to institutions of higher learning to initiate and improve programs in nuclear science and engineering and to infuse nuclear concepts into traditional courses. Materials such as heavy water, natural and enriched uranium, graphite and neutron sources were loaned in 1970 to 21 instititions in 16 States.

In addition to the loan of materials, funds were provided to universities having reactor facilities for fabrication of reactor fuel elements and for the shipping of spent fuel elements to reprocessing sites. In 1970, 16 institutions received $463,645 under this program.

Faculty Training Institutes

Eleven radiation science institutes and research participation programs were sponsored in 1970 for furthering specialized nuclear skills. Five of them were summer institutes for college teachers, two were academic-year institutes, and four were research participation sessions of about 8 weeks' duration. These institutes strengthened the nuclear background of 141 faculty members from 132 institutions.

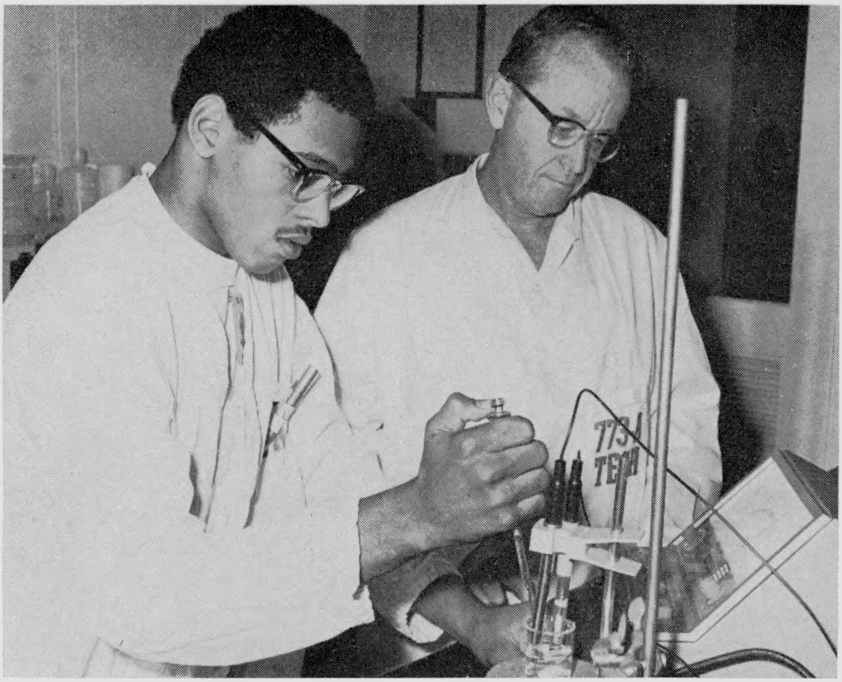
Two 1-week sessions on air and water quality assessment for college and university science faculty members were held at Oak Ridge Associated Universities. Particular attention was devoted to nuclear and other analytical techniques for monitoring, measuring and evaluating air and water quality.

At Argonne National Laboratory, five 2-week sessions were conducted during the summer period covering radiation detection, chemistry by computers, pollution measurements, and symmetry and group theory. These were attended by 86 college and university science faculty members.

MANPOWER RESOURCES

A survey made for the AEC by the American Nuclear Society on scientific and technical manpower requirements of selected sectors of the atomic energy field was completed in 1970. Based on this survey and U.S. Bureau of Labor Statistics data, the annual manpower demand during the period 1969–73 for the nuclear industry, academic institutions, and contractor-operated Government facilities is estimated at 8,000 scientists and engineers and about 7,300 technicians. There figures represent both replacement and growth in the nuclear field.

The study covered educational institutions, electric power utilities, and the nuclear industry; it did not include medical institutions or



Youth Training Programs Vary among the AEC's contractor-operated facilities, but all have the same objectives—to provide opportunity for youths to better themselves, and to provide the trained manpower needed in the nuclear energy program. The E. I. du Pont de Nemours & Co.-operated Savannah River Plant near Aiken, S.C., has a "Progressive Summer Employment Program" with two nearby colleges (Voorhees and South Carolina State) under which the student is employed in his chosen technical field in progressively challenging assignments at the plant during the summers, throughout his college training. Both the plant and the school make special provision to assign and follow the student to assure that he receives the maximum benefit of this applied experience, and that it relates as closely as possible to his academic major. Photo *above* shows a South Carolina State College student preparing a sample for chemical analysis during his first (1970) summer employment at the plant. In photo at *left*, the young man on the right is one of the employees at the Kansas City (Mo.) Plant enrolled in an 8,000-hour pipefitter's apprenticeship program conducted by the Bendix Corp. He previously worked as a junior clerk in the plant's payroll department before he was selected for the apprenticeship program. When he completes his training he will be fully qualified as a journeyman pipefitter.

Government-owned, contractor-operated facilities. The purpose of the survey was to measure certain parts of the demand and most of the supply of trained nuclear manpower.

Equal Opportunity Through Education

The AEC continued its efforts to increase the participation of black institutions and their faculty and students in AEC nuclear education and research activities. Among these efforts were:

(*1*) A contract was awarded to Tuskegee Institute (Ala.) for "Traineeships for Graduate Students in Nuclear Engineering."

(*2*) A contract for curriculum development was awarded to the civil engineering department of Southern University (Baton Rouge, La.).

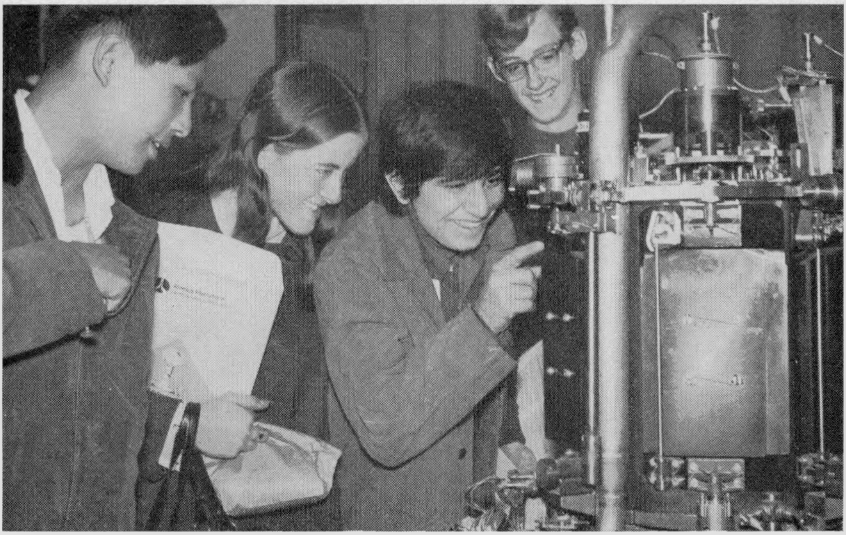
(*3*) AEC-owned used nuclear equipment was provided to West Virginia State College (Institute), Tuskegee Institute, and Federal City College (Washington, D.C.).

(*4*) Oak Ridge Associated Universities presented four summer workshops for 72 faculty and 57 administrators from 67 predominantly black institutions, entitled "Higher Education's Response to the Needs of Society in the 70's." This program was jointly funded by the AEC and the U.S. Office of Education. (These workshops led to the actions listed in items 2, 5, and 6.)

(*5*) Oak Ridge National Laboratory developed two research subcontracts with North Carolina A. & T. State University (Greensboro) for studies connected with the programs of the Y–12 Production Plant.

(*6*) The Union Carbide Nuclear Corp., employed 19 high school graduates in the summer of 1970 at Oak Ridge, Tenn., and Paducah, Ky., under an agreement for cooperative educational programs with six predominantly black institutions: Howard University, Washington, D.C.; Tuskegee Institute, Tuskegee, Ala.; North Carolina A. & T. State University, Greensboro; Tennessee State University, Nashville; Southern University, Baton Rouge, La.; and Prairie View A. & M. College, Prairie View, Tex. This was followed by the enrollment of 30 of these students as freshmen at five (Howard, Tuskegee, North Carolina A. & T., Tennessee State, and Southern) of the institutions in fall of 1970. The program is specifically aimed at students who, because of financial limitations might otherwise be unable to attend college.

(*7*) The Brookhaven National Laboratory furnished the research facilities, services, and related training in science for the "Brookhaven Semester Program," where Negro faculty and students selected from 10 predominantly Negro institutions were sup-



In the Effort to Educate Young People on nuclear energy, the anniversary of the birth, on February 11, 1847, of Thomas A. Edison is observed by student tours at AEC facilities. During the 123d anniversary celebration in 1970, more than 3,500 high school science students and teachers were guests at 16 AEC-contractor facilities. More than 60,000 students and teachers have taken part in the Edison Day celebration since 1957. At Canoga Park, Calif., Atomics International hosted 400 students and faculty escorts in observance of the AEC-sponsored National Science Youth Day. In photo *above*, a group is intrigued by a full-scale mockup of the S8DR, compact nuclear reactor designed for space applications. A group of metal-working students from the Albuquerque (N. Mex.) Indian School visited shops at the Sandia Laboratories (Albuquerque) to see techniques and equipment used in industry. In photo *below* they are being shown the detail necessary in constructing a test model drone aircraft. Like all laboratory visitors, they were required to wear safety glasses throughout their tour.

ported by the National Science Foundation. The students participate for one semester and the faculty members for an academic year.

(*8*) The Argonne National Laboratory summer program where 35 Negro science undergraduates from several predominantly Negro institutions were supported by the AEC in research and training assignments.

(*9*) Under the AEC's physical research program five research contracts, totaling $148,000 were awarded to Howard University, Washington, D.C., Tennessee State University (Nashville), and Tuskegee Institute (Ala.).

ATOMIC ENERGY FILMS

Atomic energy film audiences continued to increase in schools at all levels, among public groups, industrial organizations, and through television broadcasts. The AEC's 11 domestic and nine foreign film libraries and nonprofit sublibraries loaned popular-level and professional-technical-level films on atomic energy for a total of 153,576 showings. During the year, 12 new motion pictures [2] were added to the film library system. Wide use was also made of AEC films on telecasts, at international events, and through circulation by the AEC to U.S. Information Agency (USIA) libraries abroad.

Film Showings

Using 14,827 prints of 347 titles, the AEC's 11 domestic film libraries,[3] nonprofit sublibraries, and foreign libraries made film loans

---

[2] The new titles include: "The Warm Coat," "The Atom Underground," "Nuclear Power and the Environment," "Atomic Search," "Go Fission," "Horizons Unlimited," "Preparing for Tomorrow's World," "Your Place in the Nuclear Age," "Nuclear Fingerprinting of Ancient Pottery," "In Search of a Critical Moment," "Retirement of the Hallam Nuclear Power Facility," and "The Feast." Descriptions of all films available for public showings are included in the new Combined Film Catalog and the Classroom Films on Nuclear Science catalog released in 1970 and available, without charge, from Director of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

[3] The AEC's domestic film libraries (shown in *italics*) are located at the following AEC offices (see App. 1 for addresses) and serve requests from the indicated States and locations: *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:* Colorado, Idaho, Montana, North Dakota, South Dakota, Utah, and Wyoming; *Berkeley, Calif.:* California, Hawaii, and Nevada; *Argonne, Ill.:* Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin; *Oak Ridge, Tenn.:* Arkansas, Kansas, Kentucky, Louisiana, Mississippi, and Tennessee; *Albuquerque, N. Mex.:* Arizona, New Mexico, Oklahoma, and Texas; *Richland, Wash.:* Oregon and Washington (see App. 1 for addresses of offices). *Puerto Rico:* Puerto Rico Nuclear Center, San Juan, P.R. 00935; *Alaska:* University of Alaska, College, Alaska 99701.

which were viewed by an estimated 7 million persons during 1970 in schools, institutions of higher learning, industrial organizations, scientific and engineering groups, service clubs, and other community groups in the United States. In addition, the AEC's film libraries reported 548 television showings to an estimated 104 million people.

The use of AEC films—both English and foreign language versions—by foreign scientific, industrial, and educational organizations increased in 1970 with South American countries, Canada, Australia, and The Netherlands leading the list. Screenings of more than 4,752 motion pictures, largely on a professional level, were reported from AEC and USIA offices in London, Tokyo, Brussels, Stockholm, Rio de Janiero, and Buenos Aires, plus sublibraries in the National Science Film Library of Canada in Ontario, the American Film Library at The Hague, The Netherlands, and the International Atomic Energy Agency (IAEA) film library in Vienna.

Award Winning Films

Seventeen AEC films were entered in 25 different international events. Several films won special honors, such as: Grand Prize Award for "The Feast" at the 20th International Tourist and Folklore Film Week, Brussels, Belgium; Golden Rocket Award for "The Warm Coat" at the 17th International Electronic Nuclear and Telecommunications Congress, Rome, Italy; a diploma from the Fifth Festival of Technical Films, Budapest, Hungary; Golden Eagle Awards to "The Warm Coat" and "The Feast" by the Council on International Non-theatrical Events (CINE), Washington, D.C.; Gold Camera Awards to "In Search of a Critical Moment" and "Combustion Techniques in Liquid Scintillation Counting" at the U.S. Industrial Film Festival, Chicago, Ill.

TECHNICAL INFORMATION

Computerized technical information retrieval systems for scientists and engineers in the nuclear energy field achieved new reality both within the United States and on an international basis. The lecture-demonstration program for high schools continued to grow during the year.

INFORMATION RETRIEVAL

A remote-access computerized technical information system functioned successfully in 1970, highlighted by a successful transoceanic linkup over a distance of some 6,000 miles. The AEC made its first contributions to, and received its first informational products from, the International Nuclear Information System formally initiated by the International Atomic Energy Agency (IAEA).

Remote Access Computerized System

Throughout the year, the AEC successfully operated a remote access computerized information system. Descriptive information on over 125,000 items of nuclear literature (from the 1968 to 1970 issues of *Nuclear Science Abstracts*) were placed in computer storage at the Palo Alto (Calif.) Research Laboratory of the Lockheed Aircraft Corp. A keyboard and visual display terminal at the AEC's Oak Ridge, Tenn., technical publications facility—and later in the year,

Worldwide Access to Nuclear Science Information was enhanced during 1970 when AEC began operation of a system permitting the search of computer-stored information from remote terminals. Scientists at AEC installations in Oak Ridge (Tenn.), Pittsburgh (Pa.), Berkeley (Calif.), and Germantown (Md.) were able to ask questions of a computer located at the Palo Alto (Calif.) Research Laboratory of the Lockheed Aircraft Corp. In June, the same computer was successfully queried from a terminal located in Paris (France). The information is displayed on a cathode-ray tube as shown *above* as well as being printed out.

additional terminals at the AEC's Bettis Atomic Power Laboratory in Pennsylvania, Lawrence Radiation Laboratory, Berkely, Calif., and at the AEC Headquarters in Germantown, Md.—"conversed" with the Palo Alto Computer and received immediate responses to bibliographic questions about the items in storage. These answers were also displayed on cathode-ray tubes—similar to those employed in TV sets—and were printed out. The System was designed for direct use by scientists and other researchers after brief familiarization.

Late in the year the basic data file was transferred to a computer at the Oak Ridge National Laboratory. The system was first developed by Lockheed for NASA.

In June, the feasibility of immediate information transfer on a worldwide basis was dramatically demonstrated when the Palo Alto data file was successfully interrogated by a computer terminal located at the Paris office of NASA's European Space Research Office (ESRO), 6,000 miles away. The transoceanic part of the transmission was accomplished by transatlantic cable. Similar results are believed obtainable by use of communications satellites.

International Nuclear Information System

The International Nuclear Information System (INIS),[4] administered by the IAEA, became operational in May. While presently limited to reactor technology and engineering, the system will ultimately embrace all nuclear science, technology, economics, and law. The AEC's input to the decentralized system during the year included bibliographic descriptions and indexing for about 2,400 items of U.S. nuclear literature (submitted on magnetic tape), abstracts for the same items, and microfiche copies for those of the items which appeared as AEC reports. In return, the AEC received from INIS: (*a*) Magnetic tapes containing the merged bibliographic descriptions and indexing submitted (in English) by participating countries; (*b*) a publication called *INIS Atomindex* containing the bibliographic descriptions in printed form; and (*c*) the full text of reports and other nonconventional literature represented in the submissions from about 30 member states.

Educational Publications

The Elusive Neutrino, one of AEC's "Understanding the Atom"[5] series of educational booklets, received the annual Science Writing

[4] See pp. 217–218, "Annual Report to Congress for 1968," and pp. 217–219, "Annual Report to Congress for 1969."

[5] A complete list of all "Understanding the Atom" booklets published can be obtained from U.S. AEC-Technical Information, P.O. Box 62, Oak Ridge, Tenn. 37830. Single copies of booklets (limit: 3 titles per request) are available free of charge.

Award in Physics and Astronomy sponsored by the American Institute of Physics and the U.S. Steel Foundation. The $1,500 award and commemorative plaque were presented to the author, Dr. Jeremy Bernstein, in New York on October 6. Five booklets were published in a new "World of the Atom" series intended for science students and teachers in the upper elementary grades.

Technical Progress Reviews

The quarterly journal, *Reactor Materials*, which had been prepared for the AEC's "Technical Progress Review"[6] series by Battelle Memorial Institute (Columbus, Ohio) for over 11 years, was discontinued in 1970. Reviews of progress in the reactor materials field, including a quarterly contribution by Battelle, will be published in *Reactor Technology.*

DEMONSTRATIONS AND EXHIBITS

The number of State organizations sponsoring high school lecture-demonstration programs on atomic energy continued to increase. Preliminary design was completed for the U.S. exhibit to be presented at the Fourth United Nations Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland, during September 1971.

High School Lecture Demonstrations

During the 1970–71 school year, the number of "This Atomic World" high school lecture-demonstration units being operated by State-sponsored organizations under cooperative agreements with AEC increased to 18 (see App. 7). Under these agreements, the AEC trains and supervises the teacher-demonstrators and supplies the demonstration equipment and the van to transport it; the cooperating organizations supply the teachers and schedule the presentations. Two other units, operated for the AEC by Oak Ridge Associated Universities, provide programs to high schools in States not served by cooperative units.

Geneva Conference Exhibit

"Atoms for Development" is the tentative theme chosen for the national exhibits to be presented at Geneva, Switzerland, in Septem-

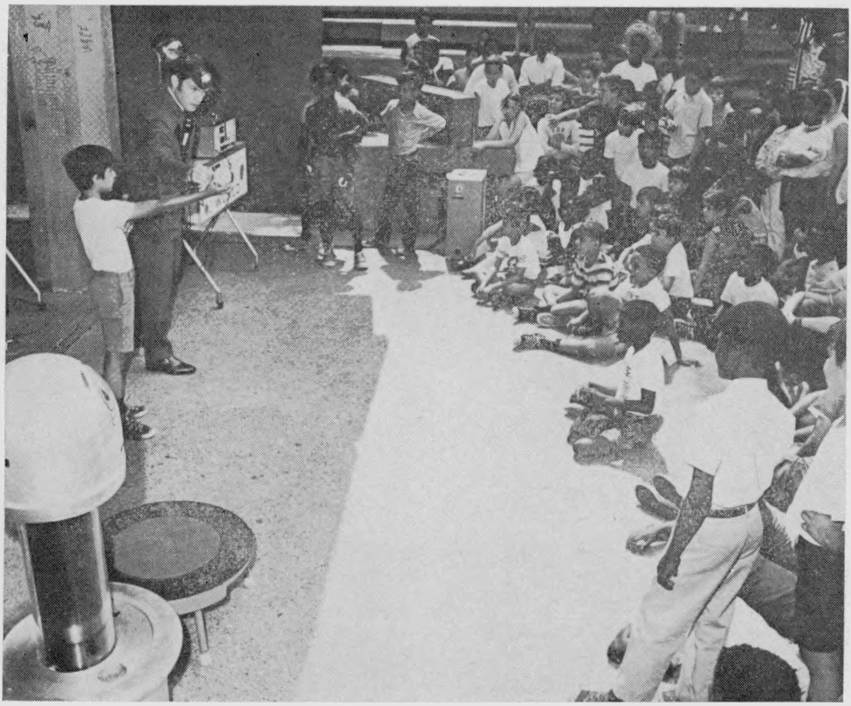
[6] "Technical Progress Reviews" may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at the following prices: *Nuclear Safety,* $3.50 per year (six issues), $0.60 per issue; *Reactor Technology,* $3 per year (four issues), $0.75 per issue; and *Isotopes and Radiation Technology,* $2.50 per year (four issues), $0.70 per issue.

412-406—71——16

ber 1971 in conjunction with the Fourth United Nations Conference on the Peaceful Uses of Atomic Energy. The AEC, with the cooperation of the U.S. nuclear industry, is preparing the U.S. exhibit.

DECLASSIFICATION AND PATENTS

The AEC continually reviews information developed under its technical programs with an eye toward making it available to the scientific community without endangering the national defense and security. In a companion program, the AEC grants nonexclusive, royalty-free licenses on nuclear-associated patents it holds, or acquires, as a part of its effort to make unclassified technological information generally available for use by industry.



The "This Atomic World" Lecture-Demonstrations moved out of the high school circuit into New York City's neighborhood youth and recreation centers during the summer of 1970. Photo shows a portion of one of the recreation center showings; in all, more than 10,000 New York City youngsters saw the showings through arrangements between Oak Ridge Associated Universities, which conducts the lecture-demonstration program for the AEC, and the New York Hall of Science and Empire State Atomic Development Associates.

DOCUMENT DECLASSIFICATION

As a part of the AEC's continuing program to declassify all reports and records eligible for declassification under current policy and to make the information therein available to the scientific and technical community as rapidly as possible, a 1970 task force undertook an accelerated review of the classified documents in AEC files originating from the Aircraft Nuclear Propulsion program which had been terminated in March 1961. Of the more than 7,000 documents reviewed, some 5,100 documents, or 70 percent, were declassified.

In 1970, some 7,000 documents in other subject areas were declassified and made available for public use. In addition, the classification review resulted in a reduction in the number of classified documents stored at AEC contractor facilities thus reducing expensive storage facilities.

PATENT AVAILABILITY

The availability of AEC-owned United States and foreign patents for licensing is publicized in technical journals and through AEC public announcements.[7]

1970 Issuance

The AEC was granted 232 U.S. patents during the period November 18, 1969, to November 24, 1970, which brings the total number of unexpired U.S. patents available for licensing to 4,302. The AEC acquired 476 additional foreign patents in some 15 countries during the year and the portfolio of foreign patents is now 3,407.

The AEC granted 120 nonexclusive licenses on Government-owned patents and patent applications. In addition to those licenses granted by the AEC, 22 nonexclusive licenses have been retained by contractors. Exclusive licenses in fields other than atomic energy have been retained by AEC contractors on eight patents. The AEC has been granted nonexclusive licenses for governmental purposes in six patents to which contractors have retained title.

Private Atomic Energy Applications

Under the provisions of section 152, Atomic Energy Act of 1954, as amended, the Commissioner of Patents referred 559 privately owned

[7] Listings published as AEC public announcements (available from the Division of Public Information, USAEC, Washington, D.C. 20545) during 1970: No. N–19 (British Patents), February 16; No. N–29 (U.S. Patents), March 9; No. N–88 (German Patents), May 28; Belgian Patents October 2; Australian Patents October 2; British, Canadian, and U.S. Patents November 20.

U.S. Patent applications for review by the AEC. A total of 37 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 sections 152 to 333. The AEC has acquired rights in 182 section 152 applications; in 114 cases, the directives were withdrawn without acquisition of rights after completion of investigations, five cases were abandoned, and one was withdrawn by the U.S. Patent Office. Some 31 section 152 proceedings are pending.

Chapter 12

BIOMEDICAL AND PHYSICAL RESEARCH

The AEC sponsors a wide variety of basic research studies in the life and physical sciences. Some of the noteworthy advancements made in the recent past are very briefly mentioned in the text that follows; these "highlights" are taken from the more detailed summaries appearing in the supplemental report, "Fundamental Nuclear Energy Research—1970." [1] The material appearing on these pages is concerned primarily with new facilities that will support the basic research effort.

BIOLOGY AND MEDICINE

Research in biology and medicine is an essential part of the overall AEC program contributing to the national security and general welfare. Along with the continuing studies of the interaction of radiation with biological systems, a substantial effort is being devoted to assess, evaluate, and control radiation exposure to man and the environment.[2]

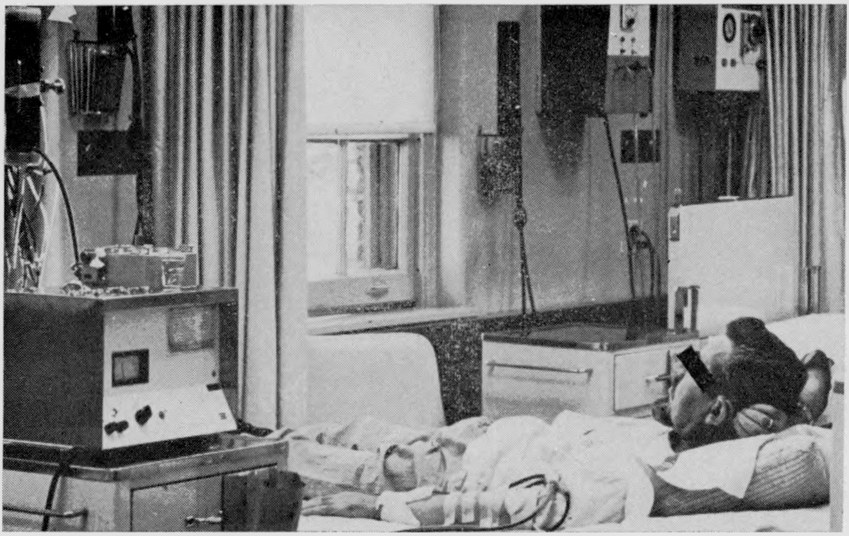
During the past year, a number of significant advances in the biomedical research program have been reported. Among these advances is the observation that gallium-67 has an affinity for certain soft tissue tumors and has a potential for use in tumor detection by radioisotope scanning. Significant advances have been made in studying the effects of radiation on man by showing that persons with a measurable body burden of radium have characteristic defects and changes in skeletal structure. New techniques are now available for measuring DNA, which is the critical component of living cells.

Research in the biomedical program is carried out under 607 contracts. These contracts support work at nearly 212 universities, com-

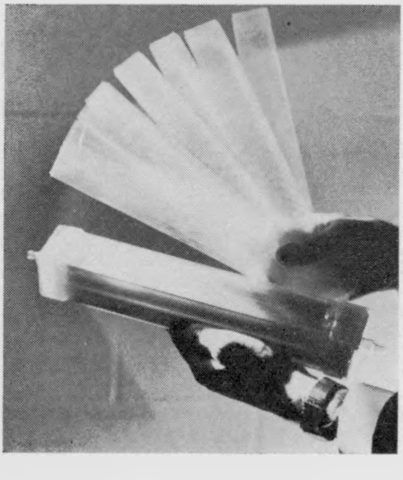
---

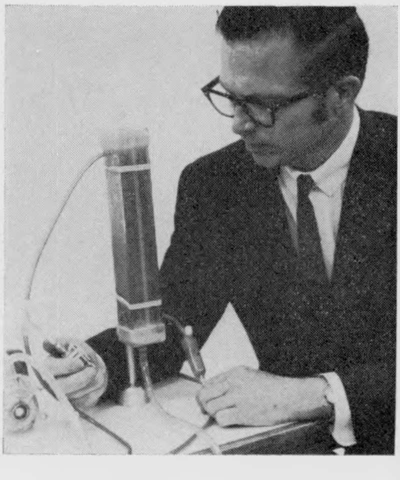
[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $2.75.

[2] See "Summaries of USAEC Environmental Research and Development," TID-4065; available from National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151. Price $3 a copy.



An Artificial Kidney that may save the lives of many kidney disease patients has resulted from experience gained in Argonne National Laboratory's particle accelerator program. Photo *above* shows a patient at the Veterans' Administration Hospital, Hines, Ill., participating in 1970 clinical tests of the Argonne hemodialyzer (*arrow* at *top left*). Blood is circulated around a series of cellophane tubes by the patient's heart action and a dialyzer solution is circulated through the tubes, exchanging blood wastes through the tiny pores in the separating membrane. The construction of the web-supported membranes is shown *below left;* fanned, and assembled in the casing. *Below right*, Finley W. Markley, an associate physicist at Argonne, is shown inspecting the model of the artificial kidney which he and Dr. A. R. Lavender of the Hines VA Hospital developed under an interagency agreement with the National Institutes of Health. The hemodialyzer was selected by *Industrial Research* magazine as one of 1969's 100 most significant new technical products. The development of special adhesives for Argonne's 12.5-Bev. Zero Gradient Synchrotron led to solving the principal problem in developing the artificial kidney—the bonding of many short lengths of plastic tubing.





mercial research organizations, nonprofit institutions, and other Federal agencies; however, most of the work is performed at the major AEC laboratories.

RECENT ADVANCEMENTS

The following paragraphs are the "highlights" of recent findings of the biomedical research program which are described more fully in Part IV of the supplemental report "Fundamental Nuclear Energy Research—1970." The supplemental report also includes a section covering AEC-sponsored research on recovery from radiation damage.

Beneficial Applications of Radiation

- Interest in labeling compounds with carbon-11 has been renewed since such compounds now may be clinically useful. Carboxylic acids have been labeled with carbon-11 for evaluation of the relationship between their chemical structure and their distribution in the body.
- Research in parasitology and virology gives promise of a new diagnostic test for *Chagas'* disease and a possible fish predator to interrupt the life cycle of the snail which is responsible for schistosomiasis (both are tropical diseases).
- With certain labeled carbohydrates (glucose and galactose) the exhalation of carbon-14 dioxide after ingestion with a large amount of sugar is proving to be an indicator of diabetes with sensitivity equal to, or greater than, standard glucose tolerance tests.

Effects of Radiation

- The effects of radiation on brains of rats, sharks, and monkeys are being studied to determine changes in function and structure of irradiated tissue. Since, in radiation therapy, the central nervous system may be exposed to X- or gamma rays, it is essential to know the effects of various radiation doses on these tissues.
- Ponies have shown good recovery from near-lethal exposures to gamma radiation and are able to work after such exposures.

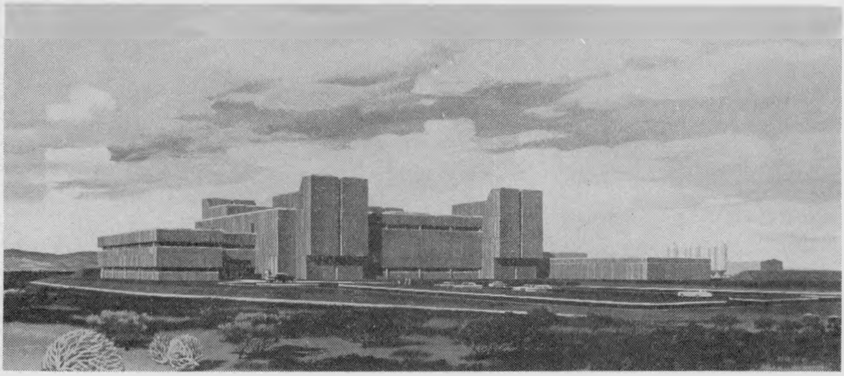
Cell-Level Radiobiology

- Simple molecules could have combined to make proteins and nucleic acids without the help of living organisms, and have been able to produce complex molecules nonbiologically. Recent findings offer a clue to the prebiological events that result in coupling of proteins and nucleic acid.

- The plant cell wall, like a string shopping bag, has a loose, stretchable meshwork. In a string bag, knots prevent the meshwork from slipping apart. Recent studies suggest that similar "knots" in the cell wall are protein which tie together the polysaccharide framework.
- How learning and memory take place is, for the most part, still unknown. Work now indicates that both chemical and anatomical changes are involved in these processes. Animal experiments are being pursued using drugs to test inhibition or modification of the synthesis of protein. Even when protein synthesis is greatly inhibited during a learning experience, the animal's memory is only partially impaired.

Toxicity of Radioelements

- Removal of plutonium from the liver can be accelerated by use of a complex sugar (glucan) extracted from brewer's yeast; the



A New Biology Laboratory at Hanford Works, near Richland, Wash., will consolidate under one roof, the biology and ecology research formerly conducted in a number of vacated process buildings located in a remote area more than 20 miles from other laboratories. Some of this work has been housed in temporary quarters since the aquatic biology laboratory was destroyed by fire in November 1964. Occupancy of the new laboratory (drawing *above*) is anticipated early in 1971. The new biology laboratory is of reinforced concrete construction, with an area of 90,000 square feet, and has been erected at the main Pacific Northwest Laboratory site. The main laboratory is multistoried with single-story wings for housing swine, dogs, and other experimental animals. The changing research programs which required these improved facilities include expanded large animal radionuclide metabolism and toxicity studies—especially those studies involving the inhalation of plutonium and other alpha emitters. Space will also be provided for small animal radionuclide metabolism and toxicity studies, for molecular and cellular biology, for aquatic biology and radioecology, and for the analytical services to support these studies.

chemical and physical properties of glucan appear responsible for its therapeutic effect.

Health Physics

- More accurate basic information on doses from radionuclides deposited in the body is now being obtained. Different particles of various energies are emitted when a radionuclide decays; the number and energies of all particles emitted by decay have now been accumulated for 54 radionuclides of medical interest.

Recovery from Radiation Damage

- Several classes of enzymatic repair systems are now known to operate in living cells for correcting radiation damage.
- A technique called sedimentation analysis has confirmed the production and repair of breaks in single strands of dioxyribonucleic acid (DNA) of mammalian cells, as was shown earlier in bacteria.
- One of the more dramatic effects of radiation on chomosomes is the production of new chromosome structures resulting from the interaction and repair of lesions produced in different parts of the chromosome set. Either protein or DNA may be involved in the repair process. Study results point to two fundamental concepts about chromosomes: (*a*) The functional chromosomal subunit is single-stranded DNA; and (*b*) the primary target for the radiation production of chromosome alterations is the DNA.

RADIOLOGICAL SURVEYS

The Aerial Radiological Measuring Survey (ARMS) is a continuing activity which consists of a light, twin-engined aircraft carrying advanced instrumentation for radiation measurement and position location. Flying at low altitudes (300 to 500 feet) ARMS can make a radiological survey of a large area during a relatively brief period.[3]

In the main, attention has been directed to sites of interest to AEC to document background radiation levels. Among the areas surveyed during 1970 were those in the vicinity of nuclear power reactors at Morris, Ill.; Monticello, Minn.; Lagoona Beach and South Haven, Mich.; Two Creeks, Wis.; and Rowe, Mass. A nuclear fuel reprocessing plant at West Valley, N.Y., was surveyed, and the ARMS aircraft went to Cape Kennedy at the time of the Apollo 13 launch because that spacecraft carried a nuclear electric power source containing plu-

[3] See p. 17, "Annual Report to Congress for 1968."

tonium. In addition, ARMS was active in a supporting role in environmental monitoring at the AEC's Nevada Test Site.

In July, ARMS demonstrated its accident response capability by participating in a search for a reentry vehicle of a U.S. Air Force test missile which landed in Mexico—well beyond the intended impact area. The reentry vehicle contained two small radioactive (cobalt-57) sources which, as expected, the airborne equipment could detect.

The ARMS crew arrived over the presumed region of impact on July 31. The airborne measuring equipment located the impact site on August 1, and the ARMS crew guided a ground search party to the small crater where debris of the reentry vehicle was found. The quick ARMS detection ended a conventional 2-week air/ground search effort.

PHYSICAL RESEARCH

The AEC physical research program is concerned with basic investigations which seek to discover new scientific knowledge and to improve understanding of natural laws and phenomena which are relevant to the atomic energy program. Research is carried out in high-, medium-, and low-energy physics, chemistry, metallurgy and materials, controlled thermonuclear reactions, and mathematics and computers. The majority of the AEC's basic physical research investigations are conducted at AEC national laboratories and other AEC-owned, contractor-operated research and development facilities. Research is also conducted at offsite locations supported by the AEC through contracts. There are 577 contracts for physical research at 148 institutions which include universities and other educational institutions, a small number of nonprofit research and commercial research organizations, and other Federal agencies.

RECENT ADVANCEMENTS

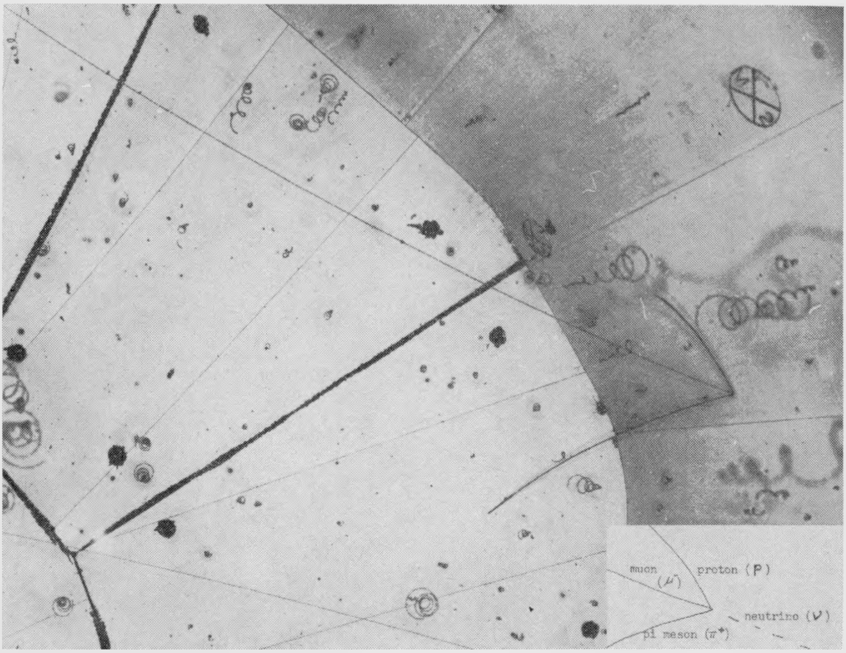
The physical research section (Part I) of the "Fundamental Nuclear Energy Research—1970" report presents some of the noteworthy results of the AEC's physical sciences research program. The following paragraphs are "highlights" of some of these achievements which are described in more detail in the supplemental report.

Chemistry Research

● In April, following the bombardment of a californium-249 target in the Heavy Ion Linear Accelerator (HILAC) with a beam of 84-Mev.

nitrogen nuclei, a few atoms of a new radioactive element (105) were formed. The name “hahnium” has been proposed for the element; the isotope discovered is hahnium-260.

- A combination of synthetic and mass spectroscopic investigations has clarified the puzzling distribution of molybdenum produced by fission in the Molten Salt Reactor Experiment.
- Perbromates, compounds in which the element bromine has a valence of +7, have been synthesized for the first time on a submicroscopic scale by a “hot-atom” process. The process uses radioselenium (Se^{83}) incorporated in a selenate salt. Through loss of beta particles, the selenium decays to bromine-83.



The New 12-Foot Bubble Chamber at Argonne National Laboratory's Alternating Gradient Synchrotron (AGS) began producing nuclear-event photos of scientific interest during 1970. Filled with 7,000 gallons of liquid hydrogen under pressure, the large chamber enables scientists to conduct a new generation of elementary particle experiments including those with the elusive neutrino. The nuclear particles resulting from collisions can be traced through photos of the trails of tiny bubbles made in the liquid hydrogen. Photo *above* is of the first neutrino-induced reaction in pure hydrogen produced in the 12-foot bubble chamber. In the event, a 1,100-Mev./c (momentum) neutrino (invisible) collides with a proton in the liquid hydrogen to produce in addition to the recoiling proton, a positive pi-meson and a negative muon ($\nu + p \rightarrow \mu^- + \pi^+ + p$). The labeled inset shows the reaction. Because of the chamber's size, a variety of nuclear event actions may be photographed at once. Sections of the photo can be blown up for study, such as the event shown *above*.

- A method has been developed for calculating the range and penetration probabilities of low-energy electrons in water as a function of initial energy.

Metallurgy and Materials Research

- A new and simple mechanism of phase transitions in solids, namely, the condensation of a soft phonon mode at an appropriate zone boundary, has been determined by neutron scattering measurements.
- Low temperature neutron irradiation and lattice characteristics measurements have clearly shown the details of point defect mobility in copper.
- The application of high-speed pulsed heat techniques has verified a new kind of heat flow in crystals called "second sound."

High-Energy Physics

- A theory which relates ideas of classical optics, direct nuclear reactions at low energies, and high-energy reactions, predicts secondary particle patterns which are in excellent agreement with experimental observations.
- Light from a powerful ruby laser has been used successfully to produce a polarized photon beam to probe the innermost structure of elementary nuclear particles.
- Inelastic electron scattering from a proton target has given evidence that individual constituents, tentatively called "partons," exist within the proton.

Medium-Energy Physics

- Observation of a forward-backward asymmetry in the nuclear reaction deuteron + helium-4 → triton + helium-3 indicates that neutrons may interact with other neutrons a little differently than they do with protons.

Low-Energy Physics

- Nuclear reaction experiments with polarized deuterons yield new information on the spin dependence of nuclear forces.
- A triton (nuclei of hydrogen-3) beam has been used to obtain detailed information on fission barriers and to measure fission cross sections.

● Polarization (orientation) of electrons in a crystal can be transferred to nuclei passing through the crystal.

Controlled Thermonuclear Research

● A direct conversion scheme, based on the ability of a magnetic mirror confining field to convert the random kinetic energy of escaping ions into parallel motion, has been used to convert kinetic energy to electric energy.

● Plasma conditions approaching those needed for a thermonuclear reactor have been achieved by the 2× magnetic mirror experiment.

● Some of the controlled thermonuclear effort is being redirected to take advantage of the advances possible with a Soviet fusion concept the "tokamak."

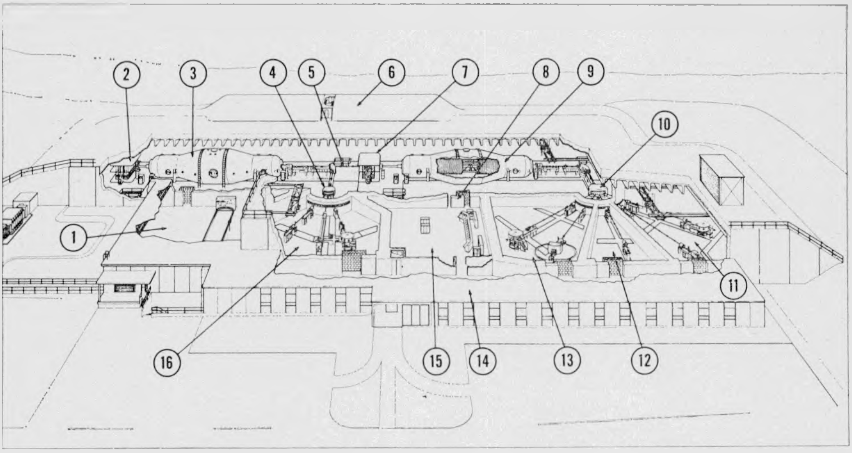
PHYSICAL RESEARCH FACILITIES

The very nature of the physical research program calls for the availability of advanced research facilities and increasingly sophisticated scientific apparatus.

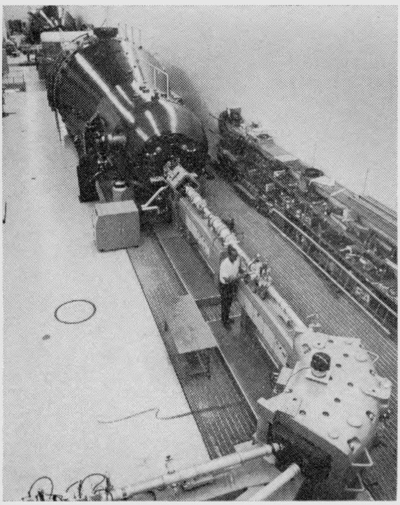
Brookhaven Double Tandem Van de Graaff

The world's most powerful Van de Graaff acceleration system met its design performance specifications on June 28, 1970, at Brookhaven National Laboratory. A two microampere momentum analyzed beam of protons at 30.0 Mev. (million electron volts) was achieved by three-stage acceleration. On the following day, a 30.5-Mev. proton beam with a three microampere current was produced. Beams from this acceleration system have the excellent energy control and stability characteristic of Van de Graaffs and have the higher energies required for study of certain nuclear reactions. A wide variety of particle beams, *e.g.*, proton, deuteron, carbon, nitrogen, sulfur, and chlorine, are available for nuclear physics research.

With the heavy-ion beams generated, the measuring of lifetimes of nuclear states is underway; *e.g.*, 70-Mev. beams of chlorine-35 and sulfur-32 have been used to study lifetimes of nuclear states of argon-38 and chlorine-35. Measurements on nuclear reactions with light ion beams will also be an important component of the research program, *e.g.*, proton + carbon-12→neutron + nitrogen-12 and proton + nitrogen-14→two neutrons + oxygen-13 measurements have been made to determine the energy threshold of the latter reaction which occurs at an



The World's Highest Energy Van de Graaff System, designed to accelerate hydrogen ions to an energy of 30 Mev. (million electron volts) reached its design aim on June 28, 1970—the first time it was put to the full test at Brookhaven National Laboratory. The versatile tandem accelerator system can be used to accelerate a wide variety of nuclear projectiles on to target nuclei. For heavier elements, such as chlorine, beam energies in excess of 30 Mev. are available, by using special techniques to strip large numbers of electrons from the atoms. During test runs, oxygen ions from which all eight electrons had been stripped have been accelerated to 98 Mev. In the *above* cut-away view of the facility, are two model MP tandem Van de Graaff electrostatic accelerators (*3*) and (*9*) each independently capable of accelerating both light and heavy nuclei from external ion sources (*2*) and (*7*) through beam switching magnets (*4*) and (*10*) into target rooms (*11*), (*12*), (*13*), and (*16*). Highest particle energies are achieved in three-stage operation with the first accelerator (*3*) injecting energetic negative ions through the connecting link (*5*) directly into the second accelerator (*9*). The centrally located control room (*15*) has direct access to the accelerator rooms through one of the shielding doors (*8*). The mechanical equipment room (*1*) contains the pumps and compressors necessary to transfer insulating gas from storage area (*6*) to each accelerator pressure vessel. Laboratory and office space (*14*) is available for resident and visiting scientific personnel. It is anticipated that a large fraction of the research time of the new facility will be used by scientists from universities and other laboratories. The MP-type tandem Van de Graaff accelerators were designed and manufactured for the AEC by High Voltage Engineering Corp., Burlington, Mass. The $12 million project was initiated in 1962 and a completion date of July 1970 was set in 1966 when the design was completed. The final cost was within 1 percent of the original estimate, and the target date was met on schedule.



energy of about 31 Mev. Research at the double tandem Van de Graaff laboratory will be conducted by both the Brookhaven staff and visiting scientists.

Los Alamos Meson Physics Facility

Construction of the Los Alamos Meson Physics Facility (LAMPF) is proceeding at a pace that will permit a first beam (800 Mev.) by July 1972 and an active experimental research program by July 1973. Upon completion, the LAMPF proton Linac will be the world's most prolific meson producing accelerator. The 800 Mev., 1,000 microampere LAMPF proton beam will produce secondary neutron, pi-meson, mu-meson, and neutrino beams thousands of times more intense than any similar beams presently available.

On June 10, 1970, a proton beam from a Cockcroft-Walton injector accelerator was delivered into the first drift-tube tank of the LAMPF accelerator and the beam was then accelerated to 5 Mev. in the drift-tube tank. This was the first *in situ* test of LAMPF components. Analysis of the beam showed it to be of the proper energy and quality for further acceleration; the beam easily met design specifications.

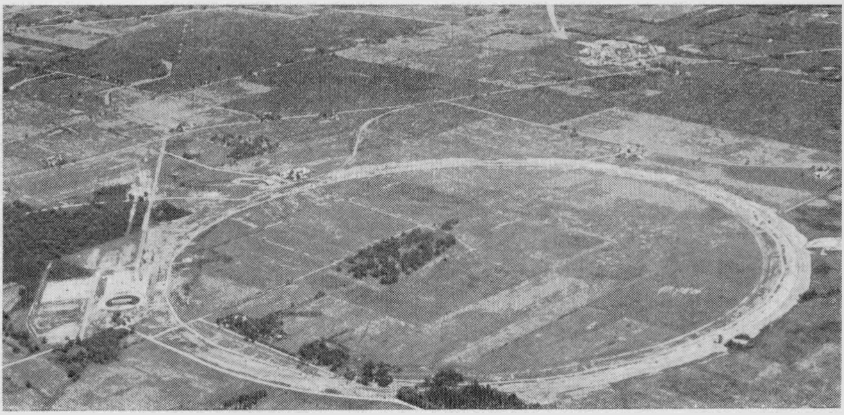
The equipment test laboratory, the injector building, and the laboratory office building have been completed and occupied. The 805 MHz. (megahertz) building and the operations building are essentially complete. Construction of the buildings which house the principal meson production targets and meson physics research areas is proceeding rapidly. Buildings to house other experimental areas are in advanced stages of design or early stages of construction.

The very successful Electron Prototype Accelerator (EPA) [4] has proven the soundness of the LAMPF RF-cavity design for the 800 Mev. proton Linac, and has been used to develop computer control systems for the 800 Mev. Linac. Activity at EPA is now focused on the development of appropriate meson production targets for LAMPF. EPA is ideal for this application since the electron beam has the same structure and energy deposition as will the 800 Mev. proton beam.

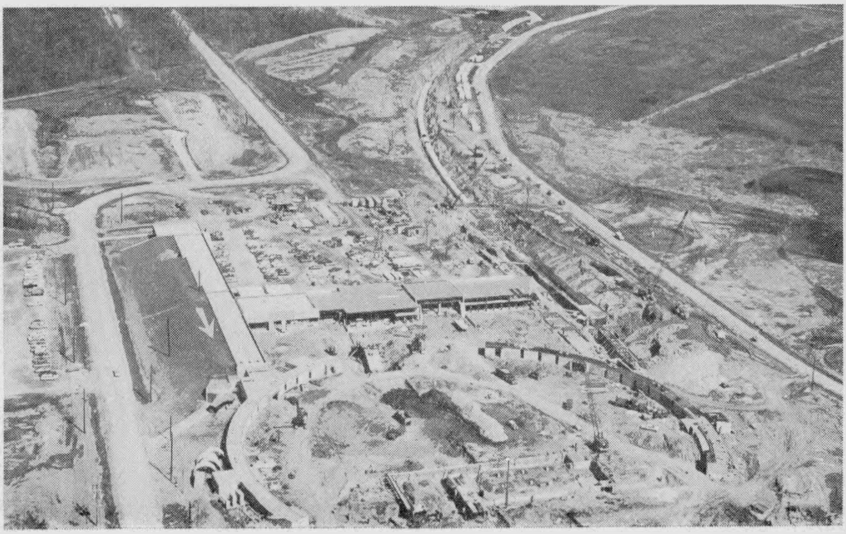
HILAC Modifications

The Heavy Ion Linear Accelerator (HILAC) at the Lawrence Radiation Laboratory, Berkeley, is currently being modified to accelerate ions as heavy as uranium, which will be used as projectiles in efforts to synthesize new members of the transplutonium elements bordering

[4] See pp. 113–117, "Fundamental Nuclear Energy Research—1969."



Construction of the National Accelerator Laboratory (NAL) at Batavia, Ill., is proceeding on schedule. Engineering design is over 67 percent complete and overall construction on the project is more than 40 percent complete. The major project components (Linac injector, booster accelerator, and the main ring of the 200-Bev. accelerator itself) are essentially all in place. During early 1971, the machine will undergo preoperational checkout and NAL plans to accelerate the first linear accelerator beam in the summer of 1971. The full system is scheduled to be operational in June 1973. *Above* is an aerial view of the site, looking northeast. The Laboratory Village (the former Village of Weston) is indicated by the *arrow* at the *upper right.* West Chicago is at the top, beyond the site boundary. Photo *below* shows the three major accelerators which, when connected in series, will propel protons to an energy of 200-billion electron volts. The linear accelerator is at *left* in the rear of the circular booster shown in the *foreground;* a portion of the main accelerator is to the *right. Arrows* indicate beam directions. During 1970, a program advisory committee was established to review the many proposals for experiments being received at the NAL from university and laboratory experimental groups across the country. By late 1970, over 90 proposals had been received and are considered as uniformly excellent by the program committee.



the "islands of stability," a region of matter conjectured to exist on theoretical and semi-empirical grounds.[5] The new device will furnish heavy ions with sufficient energy to overcome the repelling nuclear forces for positively charged ions, with provision for fine tuning of the excess energy to prevent excessive disruption of the nucleus.

Conversion of the Model-C Stellarator

Conversion of the Model-C Stellarator at the Princeton Plasma Physics Laboratory to a "tokamak"[6] configuration (toroidal) was completed May 1, 1970, after only 4 months of down time. This device, at Princeton, N.J., has given U.S. scientists the first operating tokamak outside the U.S.S.R. The Princeton tokamak has been put into operation and has reached electron temperatures of 10 million degrees (K.)—many times the values previously observed in toroidal experiments in the United States, and close to the record of the larger Soviet TM-3 experiment. Ten million degrees is almost 2,000 times the temperature of the surface of the sun and approaches the goal for self-sustaining fusion energy release.

Scyllac

Construction of an arc segment of the large Scyllac device[7] at Los Alamos Scientific Laboratory is 40 percent complete. Scyllac is one one of the world's largest and potentially, most promising, controlled thermonuclear (fusion) devices. The staff has moved into the laboratory-office building and is proceeding with diagnostic tests of some of the Scyllac components.

---

[5] See p. 160–163, "Fundamental Nuclear Energy Research—1969."

[6] See p. 253, "Annual Report to Congress for 1969." "Tokamak" is from the Russian "tok," meaning electric current, and "mag" (pronounced "mak" at the end of a word) for magnetic.

[7] See p. 260, "Annual Report to Congress for 1967." Also, p. 250 (illustration), "Annual Report to Congress for 1968."

412-406—71——17

Chapter 13

ADMINISTRATIVE AND MANAGEMENT MATTERS

During 1970, employment in the nuclear industry continued to rise; within AEC operations, there was a small decrease in employment but an increase in employees from minority groups. Contractor-diversification was essentially completed at the AEC's Hanford Works in Washington. The AEC's central repository for radiation exposure records entered its third year of operation with a capability to exchange occupational exposure records with other agencies and organizations. There was a small decline in subcontracts going to small business.

NUCLEAR FIELD EMPLOYMENT

Employment in the atomic energy field rose from 148,996 to 154,076 between May 1969 and May 1970, according to a survey conducted for the AEC by the U.S. Department of Labor's Bureau of Labor Statistics. Workers in investor-owned establishments (including nonprofit organizations) increased 11.5 percent from 49,794 to 55,515, in contrast to Government-owned establishments where employment declined 0.6 percent from 99,202 to 98,561 over the 1-year period.

INDUSTRIAL RELATIONS

The Atomic Energy Labor-Management Relations Panel intervened in October in labor-management disputes involving seven construction crafts at the Nevada Test Site, and the Nuclear Rocket Development Station. These interventions followed strikes which began in June and were terminated by agreement to refer unresolved issues to the panel.

Work Stoppage Record

Strikes by AEC contractor employees at Government-owned, contractor-operated installations during 1970 accounted for 512,080 man-days of lost time or 1.87 percent of the estimated working schedules. Lost time on construction projects totaled 20,960 man-days or 1.22 percent of scheduled time. Lost time in production, research and development, test activities, and services totaled 491,120 man-days or 1.92 percent of scheduled time, this being the highest percentage of time lost since record keeping began in 1952.

The major strikes occurred at the Nevada Test Site, which includes the Nuclear Rocket Development Station. At other facilities, significant strikes occurred at the Rocky Flats Plant (near Denver, Colo.), the Pantex Plant (Amarillo, Texas) the Oak Ridge National Laboratory and the Y–12 plant (both at Oak Ridge, Tenn.); the Paducah (Ky.) production facilities; and the National Accelerator Laboratory (Batavia, Ill.). Most of these strikes occurred at the expiration dates of labor agreements with the principal issue being wages.

EQUAL EMPLOYMENT OPPORTUNITY

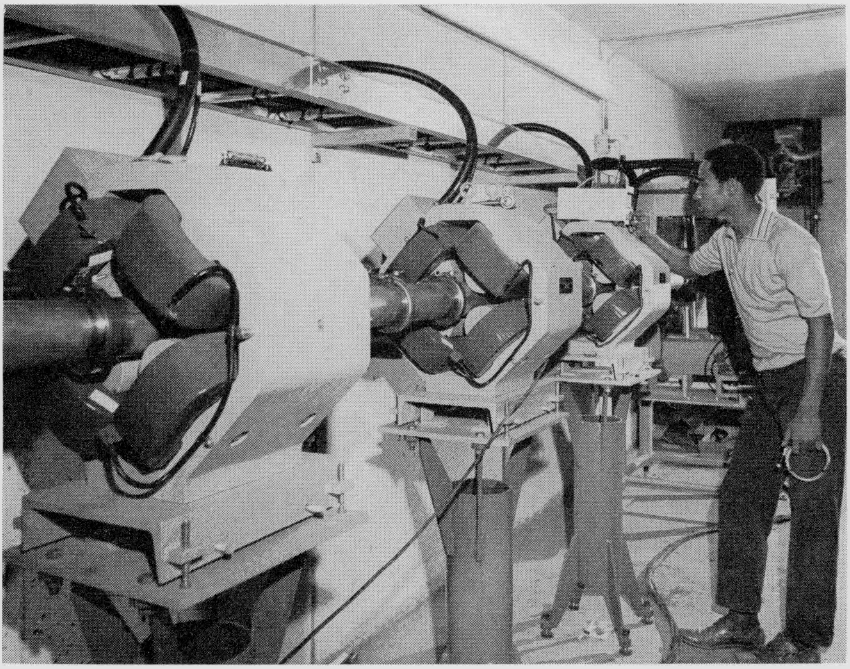
During a period of decreasing Federal employment and restrictions on staffing from 1968 through 1970 employment of members of minority groups increased from 8.6 percent to 10.4 percent. The following table reflects a 3-year summary of AEC Federal employment:

	December		
	1968	1969	1970
Total employment	7,291	7,184	7,167
Black	335	364	400
Percent of total	4.6	5.1	5.6
All minorities	625	667	744
Percent of total	8.6	9.3	10.4

The AEC places major emphasis on affirmative action programs to assure equality of employment opportunity among its Federal employees, within its operations at Government-owned, contractor-operated facilities, and in Government contractor's facilities assigned to it for equal employment opportunity compliance administration.

AEC Federal Employment

A revised equal employment opportunity plan of action for AEC Federal employees was put into effect during the year. The plan establishes long- and short-range agency goals, describes specific actions to be taken, assigns responsibilities for these actions to various officials, and sets target dates for accomplishment.



At the National Accelerator Laboratory (NAL) near Batavia, Ill., a TAT- trained technician checks a device that monitors the vacuum system for a part of the giant 200-Bev. accelerator. In the foreground are quadrupole magnets used to focus the highly energized proton beam as it emerges from the Linac and before it passes into the booster synchrotron on its way to the accelerator's main ring (see also illustrations in Ch. 12). Many of the technicians at the NAL are graduates of the training and technology (TAT) project at the AEC's Oak Ridge (Tenn.) Y–12 Plant (see pp. 270–271, "Annual Report to Congress for 1969"). The TAT project is supported by the U.S. Department of Labor, the Appalachian Regional Commission, and the AEC in cooperation with the U.S. Office of Education. It is administered by ORAU and the Nuclear Division of Union Carbide Corp. The TAT project, which began its fifth year in October 1970, provides training to unemployed and disadvantaged persons in technical skills needed in modern industry. About a third of the TAT program's 1,200 graduates are now employed in atomic energy-related activities and a substantial number of private industries.

A supervisor's training program was developed which includes understanding and awareness of minority group employees and problems. Portions of the program are devoted to examination of traditional bias, attitude development, and methods and techniques for working with minorities. The discussions, presentations, and conferences related to this program are being videotaped and will be made available to all AEC offices.

The AEC Federal women's program was made a part of the overall equal employment opportunity program, and an agency coordinator position for the women's program was designated. Managers of field offices named women's program coordinators, and women's program advisory committees were authorized for AEC Headquarters and the field offices.

Participants in the Skills Training Employment Program (*STEP*) at Los Alamos Scientific Laboratory (LASL) include electronics technicians (*above*) and mechanical technicians. Other occupational skills in which training is provided for new or entering employees are in the mechanical drafting and computer areas. STEP was instituted at LASL in 1969 to stimulate hiring of members of minority groups. Nonprofessional-level candidates are offered 6-month appointments; professional-level candidates are offered 1-year appointments. Sixty-five of the 85 minority-race participants (both nonprofessional and professional candidates) have become full-time LASL employees.

An additional position Equal Employment Opportunity Programs Advisor was established in the Office of the General Manager to expand and improve AEC liaison with national and local organizations concerned with equal employment opportunity and to provide greater sensitivity in the AEC to minority group problems.

The 1970 AEC Youth Opportunity program was highly successful with 228 young people being hired under this program; 172 were members of minority groups.

Government-Owned, Contractor-Operated Facilities

While budget limitations resulted in significant reductions in employment levels in Government-owned, contractor-operated facilities during 1969 and 1970, employment of members of minority groups as a percent of the total work force progressed from 8.5 percent in December 1968, to 9.7 percent in 1969, and to 10.5 percent in 1970. The following table shows the distribution of employment among 39 AEC contractors at 60 AEC facility locations:

	December		
	1968	1969	1970
Total employment	98, 905	96, 780	96, 473
Black	4, 214	4, 569	5, 135
Percent of total	4. 3	4. 7	5. 3
Spanish surnamed	3, 016	3, 397	3, 573
Percent of total	3. 0	3. 5	3. 7
Oriental	883	1, 095	1, 079
Percent of total	0. 9	1. 1	1. 1
American Indian	259	315	320
Percent of total	0. 3	0. 3	0. 3
Total minorities	8, 372	9, 376	10, 107
Percent of total	8. 5	9. 7	10. 5

Contractors at AEC facilities employed 920 young people under the Youth Opportunity Campaign during the summer of 1970; 65 percent were male, and 35 percent female; 43 percent were black, and 28 percent representatives of other minorities.

Assigned Facilities

Effective January 1, 1970, the Office of Federal Contract Compliance assigned to the AEC responsibility for assuring equal employment opportunity in about 3,900 privately owned, Government contractor facilities in three major industrial classifications. Previously, AEC's assignment of responsibility was based on dollar volume of Government contract work, covered entire corporations, and involved about 1,050 privately owned contractor facilities. Organizational realignments were made and additional staff were added to handle the increased workload.

COMMUNITY ECONOMIC AID

In 1970, AEC-contractor diversification activities in the Richland, Wash., area substantially met the initial contractor plans and commitments, thereby adding to the economic base of the community.

Hanford Nuclear Park Proposal

Increasing problems attending siting of new powerplants in the coastal part of Washington and Oregon have led local civic and business leaders to propose development of a nuclear industrial park on less-used portions of the Hanford Works reservation. The plan contemplates locating up to eight 1,000-Mwe. nuclear reactors on the site, with power transported to coastal population centers by existing or new transmission lines. The industrial park advocates expect that other nuclear industries related to the fuel cycle would be attracted to the area, creating new employment opportunities offsetting the results of cutbacks in AEC work.

Leadership for this proposal comes from the City of Richland and the Tri-City (Richland, Kennewick, and Pasco) Nuclear Industrial Council, and is backed by expressions of interest from citizens in the Puget Sound area.

On October 6, 1970, the Washington Public Power Supply System (WPPSS) announced its intention to locate a 1,100-Mwe. nuclear powerplant at Hanford. This plant had been previously scheduled to be constructed at Roosevelt Beach, Grays Harbor County, Wash., and is expected to cost approximately $400 million. The WPPSS expects to decide on a nuclear contractor for the plant by April 1971. The AEC is cooperating with the WPPSS in its consideration of sites on the Hanford reservation.

One of the Hanford contractors, Douglas United Nuclear, has established an Office of Energy Systems with corporate funds to assist and advise in the evolution in the Pacific Northwest of concepts such as the nuclear park.

Diversification at Richland

The initial diversification commitments[1] and plans of the several AEC operating contractors at Richland have been substantially met.

[1] 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 several contractors now operating the AEC's varied Hanford facilities (prior to 1964, all facilities were under a single contractor) have established commercial activities with total employment substantially compensating for reduction of site employment as a result of continuing facility shutdowns.

The AEC's Contractor Diversification Programs at its Hanford Works has had a broad effect on the growing economic base for the Richland, Wash., area. As new contractors have taken over specific areas of responsibility for AEC operations on the Hanford reservation, they have pledged to establish private commercial activities that have more than compensated for employment losses resulting from AEC operational curtailments. The Hanford House (*above*) on the banks of the Columbia River in Richland is a major diversification effort of the Atlantic Richfield Hanford Co. (ARHCO) which took over the Hanford chemical processing work in 1967. The unique convention and resort center was built at a cost of more than $3 million, has 150 rooms and banquet facilities for 500. More than 70 conferences and conventions were booked into the new hostelry during 1970. ARHCO's diversification funds made possible the McGregor Land Livestock Co. cattle feedlot with an annual capacity of 60,000 head. It is one of the largest in the Northwest. An all-beef packing plant with an annual capacity of 135,000 head processed on a one-shift basis is nearing completion adjacent to the feedlot. It will be operated by the Cudahy Co. The ARHCO diversification program has grown from an initial commitment of $6 million to about $10 million.

As of mid-1970, private, diversification activity full-time employment totaled 953. This number, added to the total Government and AEC contractor full-time employment of 7,827, came to 8,780, which was 759 jobs less than the total full-time employment preceding the President's 1964 decision to cut-back plutonium production.

The Battelle Memorial Institute subdivision, Battelle-Northwest, which operates the AEC's Pacific Northwest Laboratory, has announced plans to add to its own Richland research complex representing a local private investment of $20 million employing up to about 900 people by 1975.

As the result of a January 30, 1970, Battelle Memorial Institute request, the AEC transferred certain reactor development work conducted by the Pacific Northwest Laboratory to the Westinghouse Electric Corp. on July 1 (see footnote under "Hanford Facilities" in App. 3).

Westinghouse had established a subsidiary, called WADCO, to take over this work; 1,080 Battelle employees were transferred to WADCO on July 1. While the action was not a part of the AEC's planned diversification program at Hanford, it did add another operating-contractor (WADCO), thus helping to broaden the industrial base for the Richland area.

Construction of a meat packing plant by Atlantic Richfield Hanford Co. (ARHCO) nears completion. This plant, started in the fall of 1969, will employ about 150 and is one of ARHCO's planned diversification activities.

In addition to its already met diversification commitments, Douglas United Nuclear has established a commercial division that provides personnel training and a wide range of engineering consulting services to the nuclear industry. A number of utilities with nuclear powerplants under construction have sent maintenance and health physics specialists to Hanford to participate in on-plant training offered by the Nuclear Systems Consultants Division under an agreement with the Commission.

RADIATION EXPOSURE RECORDS

After 2 years of operation, the AEC's central radiation records repository established during 1969 at the AEC's Oak Ridge, Tenn., Operations Office,[2] now has the capability of providing for the efficient exchange of occupational radiation exposure information among

[2] See p. 275, "Annual Report to Congress for 1969."

Federal and State agencies and organizations, as well as between employers and employees.

In 1970, identification and annual exposure information on 7,794 individuals were reported to the central repository and cumulative exposure data furnished upon termination of employment or work assignment were incorporated in the central repository on an additional 5,226 individuals. The records of some 55,000 persons are now on file.

Annual Exposure Reports

A review of the annual radiation exposure information furnished during 1969 and 1970 indicates that of the 230,210 individuals monitored by AEC contractors and licensees subject to the AEC reporting requirements[3] in 1968, and of the 209,990 individuals monitored during 1969, approximately 98 percent either received no exposure or their annual exposure was below applicable quarterly limits (*i.e.*, 1.25 rems whole body) in each of the 2 years as shown in the table.

ANNUAL RADIATION EXPOSURES—1968-69

	1968			1969		
	Total monitored	Annual exposures exceeding quarterly limits (*i.e.*, 1.25 rems whole body)	Percent	Total monitored	Annual exposures exceeding quarterly limits (*i.e.*, 1.25 rems whole body)	Percent
Contractor personnel	[1] 193,374	3,166	1.6	[2] 176,692	3,229	1.8
Licensee personnel [3]	36,836	1,623	4	31,176	1,729	5.5
Totals	230,210	4,789	2.2	207,868	4,958	2.3

[1] Includes 63,323 visitors.
[2] Includes 73,774 visitors.
[3] *Persons monitored by licensees subject to the reporting requirements of 10 CFR 20.407.*

Termination Reports

Cumulative exposure information at time of termination of employment or work assignment on 14,792 AEC contractor and licensee personnel, has been incorporated in the central repository since the inception of the program in February 1969. Of this total, 30 percent were employed for periods of less than 3 months, 8 percent for periods ranging from 4 to 6 months, and the remaining 62 percent were employed or on work assignment for periods exceeding 6 months.

---

[3] See 10 CFR 20.407 and AEC Manual Ch. 0525, Occupational Radiation Exposure Information.

Pilot Recordkeeping Program

In addition to the radiation exposure information in the central repository on AEC contractor and covered licensee personnel, annual exposure data on some 16,000 individuals have been furnished the repository by six States[4] participating in the AEC's pilot recordkeeping program.[5] Also, 1969 and 1970 annual exposure information has been furnished the repository on 13,000 military and civilian personnel of the U.S. Air Force, and cumulative exposure information on 1,500 individuals, submitted upon termination of their employment with the U.S. Public Health Service (PHS) or agencies for whom PHS provides radiological health services.

Workmen's Compensation Standards

Twelve of the 29 State legislatures meeting in 1970 introduced 20 amendments to their workmen's compensation laws applicable to one or more of the AEC's 11 standards[6] for the improvement of State workmen's compensation laws for the radiation worker. Nine of the amendments were enacted into law.

Action by State Organizations

In November of 1969, the governing board of the Council of State Governments adopted a resolution favoring, in principle, the AEC's efforts and urged States to require employers to keep records of employees' exposure to radiation and to provide for a central repository of occupational radiation exposure information.

In July 1970, the National Association of Attorneys General, meeting in St. Charles, Ill., adopted a resolution endorsing the AEC's program to assist the States in upgrading their workmen's compensation laws.

In August 1970, the National Legislative Conference, meeting in Salt Lake City, Utah, adopted a resolution endorsing the AEC's workmen's compensation program, and urged the States to upgrade their workmen's compensation laws, where needed, during the 1971 legislative sessions.

---

[4] Arizona, Georgia, Illinois, Maryland, Utah, and Wyoming.

[5] See p. 275, "Annual Report to Congress for 1969."

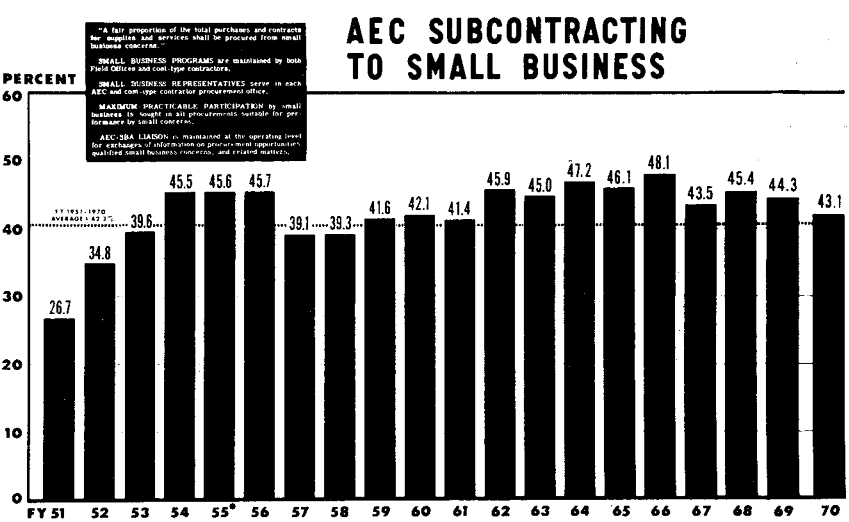
[6] See p. 276, "Annual Report to Congress for 1969."

CONTRACTING POLICY

Continuing a concentrated effort to improve equipment management throughout AEC, 12 joint AEC-contractor meetings were held at major field offices beginning in the fall of 1969 and continuing through the spring of 1970, to emphasize the findings in a 1969 General Accounting Office report and the corrective actions required.[7] The meetings, conducted by the headquarters staff, were attended by key AEC and contractor personnel representing all AEC field offices and 65 separate contractor organizations holding AEC property. AEC headquarters staff also visited major AEC contractor facilities to observe, firsthand, the progress being made toward established goals and to suggest changes where needed. Following the meetings and the visits, improvements were noted. One important result has been a substantial increase in the amounts of property identified and reported as available for reuse throughout the AEC. Fiscal 1970 figures were 30 percent above those for fiscal 1969.

---

[7] See p. 278, "Annual Report to Congress for 1969."



	FY 51	52	53	54	55*	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
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	344.8
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	800.3

* Does not include [illegible] Subcontracts at Portsmouth, Ohio which are in the nature of prime contracts.

BOARD OF CONTRACT APPEALS

The Board of Contract Appeals (see App. 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, to conduct debarment hearings and decide those cases in which a hearing has been held, and to assess liquidated damages covered by section 104(c) of the Contract Work Hours Standards Act. The 1970 workload has paralleled the sharp increase in the number of appeals which other Federal boards of contract appeals have experienced. During the first half of 1970, the board received more appeals than it had received in all of 1968 and 1969 combined, including two of the largest and most complex appeals the board has ever had to consider: Ets-Hokin Corp. (concerning work done at Los Alamos Scientific Laboratory and involving seven appeals for claims totaling $2,054,366), and Frank Briscoe & Co., Inc. (concerning work done at the Rocky Flats Plant and involving first- and second-tier subcontractors for claims totaling $111,695). The Briscoe appeals were settled after 109 days. Most preliminary matters in the Ets-Hokin case have been completed and hearings are scheduled to begin on March 30, 1971.

New developments in the Government contracts field as well as experience gained under the original rules of procedure of the board (effective November 10, 1964) resulted in publication in the *Federal Register* on February 12, 1970, of a revised 10 CFR part 3, "Rules of Procedure in Contract Appeals." The board adopted new rules (conforming to the uniform model rules of Federal boards of contract appeals) relating to procedures by the parties in disputes before it by use of dispositions, interrogatories to parties, inspection of documents, and admissions of facts—a procedure called "discovery" and which can lead to shortening hearings by days or even weeks. The board also adopted new rules relating to the unexcused absence of a party. Other clarifying revisions were made which do not affect the basic precepts establishing the board.

The board sits in three-member panels except in accelerated proceedings when either the chairman or vice chairman sits alone. During the 6-year period of its existence, the AEC's Board of Contract Appeals has docketed 86 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 61 percent of the appealed cases. Only one appeal is the subject of a court suit—Avien, Inc. (concerning work done at the Hanford plant in Washington), which is still pending before the U.S. Court of Claims.

The board actively encourages and participates with the parties in disposing of disputes by agreement as an important means of resolving contract disputes. Use of a mandatory pretrial conference has been a major factor in this matter. A primary purpose of such conferences is to bring the parties together informally in the presence of a third party to consider disposing of their dispute by agreement. Board orders requiring the parties to seek areas of agreement within specific time limits has also led to disposition by agreement.

The board docketed an AEC hearing examiner decision remanded from the U.S. Court of Claims on December 23, 1969, Owens-Corning Fiberglas Corp. and Polytron Co., by and through Walsh Construction Co. concerning work at the NTS. It was disposed of within 23 days upon settlement by the parties.

Mindful of the hardships which administrative proceedings may cause small businesses, the board makes every effort to accommodate small businesses by expediting appeals, holding conferences and hearing at or near the location of the small business and, when feasible, promptly granting accelerated procedure. The accelerated procedure may be used by any contractor, large or small, when the amount in dispute does not exceed $20,000 (increased from $10,000 by the revised rules) or for other good causes. It provides for the consideration and disposition of appeals without regard to normal position on the docket and continues to aid in expeditious resolution of appeals.

The board disposes of all appeals without unnecessary delay. The average time required to dispose of accelerated proceedings is 76 days and for nonaccelerated proceedings is 140 days.

Chapter 14

LICENSE REVIEWS AND ADJUDICATORY PROCEEDINGS

All nuclear power reactors and other nuclear utilization and production facilities, such as irradiated fuel reprocessing plants, must go through two stages in the AEC licensing process: (*a*) The construction permit stage where the AEC determines that there is reasonable assurance that a facility, of the design and power proposed, can be constructed and operated safely at the site proposed by the applicant; and (*b*), the operating license stage, where the AEC determines that the construction is in conformance with the permit, and the facility is tested for safety and brought to full power.

During 1970, the regulatory process was expanded to include consideration of environmental aspects of nuclear facilities other than matters affecting the radiological health and safety of the public (see "Environmental Quality Actions" section in Chapter 3).

THE LICENSING PROCESS

At the construction permit stage, the application for a power reactor, or other nuclear facility, is first reviewed by the AEC regulatory staff.[1] An independent technical review is also made by the statutory Advisory Committee on Reactor Safeguards (ACRS). When these reviews are completed, an atomic safety and licensing board (ASLB), drawn from a qualified panel, conducts a public hearing in the vicinity of the proposed site. The ASLB's initial decision on issuance of a permit is subject to review by an appeal board and/or by the Commissioners before becoming final.

The AEC regulatory staff and the ACRS again conduct extensive technical reviews before a notice of intent to issue an operating license

[1] The AEC regulatory staff also obtains advice and recommendations from other Federal agencies and specialized consultants where applicable in such areas as meteorology, hydrology, geology, seismology, and fish and wildlife resources.

412-406—71——18

is published in the *Federal Register*. A public hearing is not mandatory at this stage, but affected persons may request a hearing. The Commission may schedule a hearing on its own initiative.

Advisory Committee on Reactor Safeguards

The Advisory Committee on Reactor Safeguards (ACRS) held a total of 12 regular meetings and one special meeting during 1970, together with 109 meetings of ACRS subcommittees and *ad hoc* working groups.

ACRS reviews during 1970 covered 13 facilities at the construction permit stage, eight facilities at the operating license stage, and one preapplication site review. Reports were provided to the Commission on 23 investor-owned nuclear power facilities, a "spent" fuel processing plant, and one Government-owned facility. The ACRS provided special reports on the use of sensitized stainless steel safe-ends in several large water-cooled power reactors, and a hydraulic control system concept.

The ACRS Subcommittee on Reactor Safety Research met on three occasions to discuss the AEC and industry reactor safety research programs, and the committee provided a report to the AEC on reactor safety research for sodium-cooled fast reactors.

The ACRS also provided comments to the AEC regulatory staff on proposed guides regarding control of combustible gases following a loss-of-coolant accident, instrumentation for measurement of seismic events, assumptions used for evaluating the consequences of accidents for BWR and PWR facilities, thermal shock of reactor pressure vessels, industrial sabotage, standby onsite power supplies, net positive suction head for emergency core cooling and containment heat removal pumps, design of spent fuel storage facilities, isolation of instrument lines that penetrate containment, sizing of standby diesel generators, personnel selection and training, preoperational startup testing programs, and mechanical splices in reinforcing bars used in concrete containments.

Committee comments were also provided on proposed criteria regarding material fracture toughness requirements and pressure vessel surveillance, radiation protection standards, quality assurance in nuclear facilities and containment leak rate testing, and such topical matters as control and safety systems for nuclear plants and siting of nuclear facilities.

During the year, ACRS subcommittees discussed matters related to emergency plans, probabilities of natural events, the design basis for engineered safety features, the preliminary design of a large, high-temperature gas-cooled power reactors and sodium-cooled fast breeder reactors, proposed high-power density cores, and improved emergency core cooling systems. An ACRS subcommittee also visited the Hanford installation to review operating experience during the year.

ACRS members participated in activities of AEC working groups on inservice inspections of primary systems, the use of foreign reactor pressure vessels in the United States, the heavy section steel technology program, and development of a guide for technical specifications for spent fuel processing plants.

ACRS members also met with representatives of the Reactor Safety Advisory Committee of the Atomic Energy Control Board of Canada, and the Reactor Safety Commission, Commissariat a l' Energie Atomic, to discuss safety matters. A list of current ACRS membership is included in Appendix 2.

ADJUDICATORY ACTIVITIES

During 1970, the activities of the Atomic Safety and Licensing Board Panel increased markedly. Public hearings conducted by atomic safety and licensing boards were held in all sections of the country to consider applications for construction permits or operating licenses for nuclear facilities. The number of contested initial licensing proceedings and of public hearings involving operating license applications increased throughout the year.

Atomic Safety and Licensing Boards

The Commission established 15 atomic safety and licensing boards (ASLB's) in 1970 to conduct public hearings and issue initial decisions on applications for nuclear facility construction permits and operating licenses.

Each three-man board, drawn from the Atomic Safety and Licensing Board Panel (see Appendix 2 for membership) is composed of two technically qualified members and a chairman qualified in the conduct of administrative proceedings. The panel consists of 18 technical experts with extensive experience in industrial and academic nuclear programs, and 10 attorneys with experience in administrative procedures.[2]

[2] Amendments to the Atomic Energy Act on December 19, 1970, permit ASLB composition of one member qualified in the conduct of administrative proceedings and two members with such technical or other qualifications as the Commission deems appropriate to the issues to be decided. See "Practical Value" amendments to 10 CFR Parts 2 and 50 in Appendix 4 of this report.

Hearings Held

During the year, 17 hearings were held in 12 States. Applications for construction permits considered involved 16 power reactors and one irradiated fuel reprocessing plant (Allied-Gulf Nuclear Services [3]); the operating license applications considered, were for three power reactors and one research reactor.

Twelve of the cases were contested proceedings involving applications of the Pacific Gas & Electric Co., Long Island Lighting Co., Florida Power & Light Co., Northern States Power Co., Consumers Power Co. (2 cases: Palisades and Midland), Columbia University, Millstone Point Co., Virginia Electric & Power Co., Portland General Electric Co., Toledo-Edison Co., and Consolidated Edison Co.

Six of the cases were uncontested and involved the applications of Carolina Power and Light Co., Iowa Electric Light and Power Co., Power Authority of the State of New York (PASNY), Tennessee Valley Authority (TVA), Duquesne Light Co., and Allied-Gulf.

The boards determined that construction permits should be issued to the following applicants: Carolina Power & Light Co., PASNY, Iowa Electric Light & Power Co., TVA, Florida Power & Light Co., Duquesne Light Co., Pacific Gas & Electric Co., Millstone Point Co., and Allied-Gulf.

In one case (Northern States Power Co.) a limited (low-power) operating license was issued. At the end of the year, decisions involving 9 applications were still pending.

Atomic Safety and Licensing Appeal Board

The Atomic Safety and Licensing Appeal Board (ASLAB)[4] performs functions which would otherwise be performed by the Commission in: (*a*) Those proceedings on applications for licenses or authorizations in which the AEC has a direct financial interest, and (*b*) such other licensing proceedings as the Commission may specify. The final decision of the appeal board constitutes the final action, except that in cases other than those involving facilities in which the AEC has a direct financial interest, the Commissioners, on their own motion, can review an ASLAB decision on certain specified grounds.

---

[3] Allied Chemical Nuclear Products, Inc., and Gulf Energy and Environmental Systems, Inc., have formed a joint subsidiary, Allied-Gulf Nuclear Services, to construct and operate the planned fuel reprocessing plant at Barnwell, S.C.

[4] See pp. 135–137, "Annual Report to Congress for 1969." For membership see Appendix 2.

During the year, the appeal board completed or undertook review of eight facility licensing matters on appeal from initial decisions or ASLB rulings. In addition, the ASLAB responded to questions certified to it, and issued memoranda concerning other proceedings in which it determined that no formal review was warranted.

Appeals from ASLB Decisions

Carolina Power and Light Co. The appeal board reviewed an ASLB prehearing order, which was subsequently confirmed in one initial decision, denying 14 North Carolina municipalities intervention. They had sought intervention to challenge facility licensability of the Brunswick Steam Electric Plant Units No. 1 and No. 2, under section 104b of the act, and to have alleged competitive effects considered as licensing factors. The board cited the Commission's decision in the Maine Yankee case which held that the ASLB should have treated separately: (*a*) Whether the petitioners' had sufficient interest to intervene, and (*b*) the merits of petitioners' contentions (see discussion under "Commission Review" in this chapter). The appeal board held that the Brunswick units near Southport, N.C., are licensable under section 104b, and that the ASLB lacked jurisdiction to consider antitrust matters in this proceeding.

Florida Power and Light Co. The AEC regulatory staff filed an exception to the language of the environmental protection condition set forth in the initial decision of the ASLB concerning the Hutchinson Island Nuclear Power Plant near Ft. Pierce, Fla. The appeal board ruled that the ASLB's condition should stand; however, it stated that a uniform approach to the language of this condition was desirable and that, pending the adoption of revised regulations, the ASLB's should follow the phrasing for this condition as set forth in the AEC's notice of proposed rule making.

ASLB Certified Questions

Columbia University in the City of New York. The ASLB certified two questions concerning the research reactor at Columbia University in New York City to the appeal board: (*a*) Whether the applicant's reactor is a "testing facility" under the AEC's regulations, and (*b*) what "type of major accident" should be hypothesized for purposes of site analysis in this proceeding. On May 26, 1970, the appeal board replied that the applicant's reactor is not a "testing facility" and furnished guidance on the design basis "accident" which should be hypothesized.

Northern States Power Co. In the Monticello (Minn.) Nuclear Generating Plant Unit No. 1 case (see also discussion under "New Operating Licenses," on p. 79 in Chapter 3), the intervenors had asked to see the inspection reports prepared by the AEC's Division of Compliance for five other nuclear power reactors. (These reports are prepared periodically by the AEC staff as a record of onsite inspections of construction of nuclear power reactors to assure that the construction proceeds consistent with the permit issued and with AEC regulations.) The intervenors objected to the deletion of certain information from the inspection reports claimed to be privileged by the AEC's Director of Regulation. The licensing board considered the matter and referred the following questions to the Atomic Safety and Licensing Appeal Board: (*a*) Could the licensing board decide if the Director of Regulation's deletions were proper?; and (*b*) whose judgment in the matter should prevail, the licensing board's or the Director of Regulation's?

In a memorandum of August 20, 1970, the appeal board furnished guidance concerning the categories of information which could and could not be considered privileged. In addition, it held that an ASLB should, before compelling disclosure of information, refer for review to the appeal board the following: (*a*) A ruling that an item is not privileged when the Director of Regulation claims that it is privileged; and (*b*) a ruling that the proponents of disclosure have demonstrated a need for items of information which are privileged. The appeal board's holdings were affirmed by the Commission in a memorandum issued on August 26, 1970.

On October 6, the licensing board referred the same matter to the appeal board requesting specific rulings on each item of information which was deleted. On October 20, the appeal board issued a memorandum in which it made specific rulings on the privilege claims of the Director of Regulation regarding the various deleted inspection report items. The Commission affirmed the appeal board's action in a memorandum issued on October 21, 1970.

On August 24, 1970, the licensing board issued an initial decision authorizing a provisional operating license for fuel loading and low-power startup testing, making this the first instance in which a low-power license was ordered by an Atomic Safety and Licensing Board.

Appeal Board Memoranda and Orders

Consumers Power Co. In this provisional operating license proceeding for the Palisades Plant near South Haven, Mich., the applicant filed a motion requesting the AEC to direct the ASLB to resume hearings immediately to consider the applicant's motion for authorization of a fuel loading and a low-power test license. The motion was referred to the appeal board which ruled, on July 9, 1970, that the motion was an interlocutory appeal from an ASLB ruling and, therefore, must be denied. The appeal board stated that the ASLB should consider an application for a provisional operating license authorizing fuel loading and lower power testing as expeditiously as possible.

The intervenors filed a motion with the Commission to direct the Atomic Safety and Licensing Board to certify to the Commission motions directed to the scope of consideration in the proceeding of the matter of thermal effects of cooling-water discharges and on September 11, 1970, the appeal board ruled that the intervenors' motion was an interlocutory appeal from a licensing board ruling, and therefore, must be denied.

On September 3, the licensing board referred to the appeal board the following rulings: (*a*) That the licensing board consisting of its complete membership be present at all sessions of hearings; and (*b*) that the National Environmental Policy Act (NEPA) of 1969 requires the AEC staff to submit the application for a low-power (1 megawatt thermal) license to other Federal agencies for comments respecting environmental considerations. Deferring a decision on the first ruling, the appeal board, on September 25, concluded that NEPA does not require an environmental statement insofar as authorization for fuel loading and operation of the facility up to one thermal megawatt is involved. In the same Memorandum and Order, the appeal board denied the Intervenors' Motion of September 11, 1970, that the appeal board was unable to issue fair and impartial rulings and should be disqualified. On October 6, 1970, the appeal board issued a Memorandum and Order on the first ruling, in which it stated that the complete technical membership of a licensing board is not required to be present at all hearing sessions.

Long Island Lighting Co. The intervenor, the Lloyd Harbor Study Group, Inc., appealed from the ASLB rulings and requested the appeal board to certify to the Commission questions relating to the manner of application to this proceeding (Shoreham Nuclear Power Station near Rocky Point on Long Island, N.Y.) of the National Environmental Policy Act of 1969, and the Water Quality Improvement Act of 1970. The appeal board on June 23, 1970, ruled that the appeal being interlocutory was proscribed by the Commission's Rules of Practice. The appeal board noted that other administrative remedies are afforded to appropriately safeguard the intervenor's rights.

In a second appeal in this proceeding, the Lloyd Harbor Study

Group contested an ASLB ruling on a motion for an order directing the issuance of subpoenas for attendance and testimony of witnesses from various agencies of the State of New York. The appeal board on September 1, 1970, ruled that the appeal being interlocutory was proscribed by the AEC's Rules of Practice.

Another portion of this appeal contained alternative requests that the Commission, the appeal board, and the ASLB disqualify themselves from this proceeding. The appeal board on September 1, 1970, set forth the grounds which proved the intervenor's appeal to be without foundation and denied the appeal with respect to the appeal board.

Proceedings Not Requiring Formal Review

During 1970, in the following proceedings, the appeal board concluded that formal review was not warranted: (*a*) Power Authority of the State of New York, (*b*) Tennessee Valley Authority, (*c*) Duquesne Power & Light Co., (*d*) Iowa Electric Light & Power Co., and (*e*) Florida Power & Light Co.

Commission Review

During the year, the Commissioners completed or undertook formal review of three facility licensing matters upon appeals made prior to the 1969 establishment of the ASLAB from initial decisions of atomic safety and licensing boards. In addition, the Commission issued memorandums and orders in two proceedings, memorandums in two proceedings and orders in two proceedings.

Appeals from ASLB Decisions

In each of the Pilgrim Nuclear Power Station, Crystal River Unit 3, and Maine Yankee Atomic Power Station proceedings, intervening municipals had filed exceptions to ASLB decisions.[5] 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. The basic issues raised by intervenors in these proceedings are the same as those raised in two other proceedings (Oconee Units 1, 2 and 3; and Ver-

[5] See p. 125, "Annual Report to Congress for 1968" and p. 139, "Annual Report to Congress for 1969."

mont Yankee Nuclear Power Station) in which the U.S. Court of Appeals for the District of Columbia Circuit affirmed the Commission's licensing actions.[6] In its decisions issued on March 20, the Commission held that the reactors were properly licensable under section 104b of the Atomic Energy Act as facilities involved in the conduct of research and development activities leading to the demonstration of the practical value of such facilities for industrial or commercial purposes; and that the AEC lacked authority to deny or condition such a license on the basis (as claimed by the municipals) that it would tend to create or maintain a situation inconsistent with the antitrust laws.

In its Maine Yankee decision, the Commission further stated that it intended to provide an opportunity for future hearing on the financial qualifications of Maine Yankee to design and construct the subject facility, and to permit the municipals to participate therein, unless future events dictated a different course.

The ASLB in its initial decision authorizing the issuance of a provisional construction permit for Crystal River Unit 3 recommended that the permit be conditioned to require a further hearing on the question of iodine removal at, or before, the operating license stage. In its March 20 decision, the Commission stated that the evidence in the proceeding supports the issuance of an unconditioned provisional construction permit; and that the Commission's normal licensing procedures are adequate to carry out the apparent intent of the ASLB's recommendation without the imposition of a condition in the construction permit.

Commission Memorandums and Orders

Indian Point Unit 1. The Commission received a petition for hearing on the application by Consolidated Edison Co. to convert the provisional operating license for Indian Point Unit 1 (Buchanan, N.Y.) to a full-term operating license. The petitioners alleged adverse effects, from radioactive effluents and other causes, on Hudson River marine life in the course of the facility's operation under its provisional operating license. In its Memorandum and Order of June 26, the Commission stated that it planned to issue a notice of hearing on the full-term license application upon completion of the presently pending reviews by the ACRS and the regulatory staff. The Commission also ordered an inquiry by the Director of Regulation into petitioners' allegations of adverse facility effects.

---

[6] See p. 139, "Annual Report to Congress for 1969."

Palisades Plant. The Commission received a timely request for public hearing by a group of petitioners in response to a notice of proposed issuance of a provisional operating license for the Palisades Plant (South Haven, Mich.). In its Memorandum and Order of May 18, the Commission directed that a hearing be held on the application for full power license; the Commission also stated that the ASLB may, while the matter of the full-power license is pending, consider and act upon such request as the applicant may make for a provisional operating license authorizing fuel loading and low-power testing.

Shoreham Nuclear Power Station. The Commission received a referral by the presiding ASLB of its order denying an intervenor's motion that the ASLB disqualify itself in the Shoreham (Rocky Point, Long Island, N.Y.) matter, primarily because of the technical members' professional backgrounds associated with the development of nuclear power technology and because of the dual developmental and regulatory role of the AEC. The Commission's Memorandum and Order of October 28 stated that the grounds advanced by the intervenors were not a valid basis for disqualification of either the ASLB or the Commission.

An intervenor in the Shoreham proceeding also asked the Commission to order "the record" in the proceeding to be certified to it for review and to order an interim stay of the proceeding before the presiding ASLB. In a Memorandum of July 29, the Commission stated that there is no provision in its Rules of Practice (10 CFR Part 2) for an appeal to the Commission from a ruling of the ASLAB; nor was any basis shown by the intervenor to justify a departure from the Commission's regulation barring interlocutory appeals from rulings of ASLB's.

Monticello Nuclear Generating Plant. With regard to the Monticello, Minn., proceeding, the Commission, on August 26, issued a Memorandum commenting on the ASLAB Memorandum of August 20 which concerned, in response to two questions certified by the presiding ASLB, a recommended course for ASLB's to follow in adjudicatory proceedings wherein production of AEC documents is sought. (See also "Northern States Power Co." under previous "Atomic Safety and Licensing Appeal Board" section.) The Memorandum recognized the need for interim guidance in this area pending clarification of the regulations; directed the Commission staff to institute steps to clarify the regulations; and stated that the effectiveness of any ruling by the ASLAB which would compel disclosure over the assertion of privilege by the Director of Regulation be deferred for at least 15 days from the date of its issuance to provide appropriate opportunity for Commission review of such ruling.

On October 21, the Commission again issued a Memorandum which reviewed subsequent rulings of the ASLAB on the matter of production of regulatory staff inspection reports and the correlative matter of privilege. In this Memorandum, the Commission approved the ASLAB's rulings; and requested expeditious action by the staff in preparing clarifying amendments to the Commission's regulations.[7]

Vermont Yankee Nuclear Power Station

By Notice of Withdrawal dated August 24, the Massachusetts Municipals informed the Commission that they were withdrawing their appearance from the Vermont Yankee (Vernon, Vt.) financial qualifications proceeding.[8] The Notice of Withdrawal referred to and described in summary the provisions of an agreement, dated June 5, between the Massachusetts Municipals and the sponsors of the Vermont Yankee Nuclear Power Station and the Maine Yankee Atomic Power Station (Wiscasset, Maine). The Notice of Withdrawal also referred to and had appended to it a copy of the "Findings and Opinion" and consequent "Order" of the Securities and Exchange Commission (Holding Company Act Release No. 16794, June 30, 1970), approving the amended Holding Company Act applications by the sponsors of Vermont Yankee and Maine Yankee, in the context of the agreement reached between the sponsors of those projects and the Massachusetts Municipals. The Commission, on October 14, approved the withdrawal from this proceeding of the Massachusetts Municipals; terminated the financial qualifications hearing before the presiding ASLB; and authorized the Director of Regulation to make appropriate findings with respect to the applicant's financial qualifications to design and construct the subject facility.

The Commission also expressed its views on the substance of one of the questions which had been certified to it by the presiding ASLB, namely, the extent of the staff's responsibility to assure the creation of a complete record on issues specified for consideration in a proceeding. In that regard, the Commission stated that it views the AEC licensing process as contemplating the performance by the regulatory staff of its own affirmative role to assure that the record of a proceeding is sufficiently developed on all specified issues for a well-grounded agency decision. The Commission made clear that there are

---

[7] On December 23, 1970, effective amendments to 10 CFR Part 2 were published in the *Federal Register,* clarifying AEC policy and revising procedures regarding subpoena of AEC personnel and production of documents in AEC adjudicatory proceedings; see Appendix 4.

[8] See p. 123, "Annual Report to Congress for 1968" and p. 138, "Annual Report to Congress for 1969."

a variety of ways in which the staff can contribute to the completeness of a record and no uniform approach can be applied to all matters in a proceeding.

Maine Yankee Atomic Power Station

In its March 20 Maine Yankee Decision, the Commission stated that, unless events called for a different course, it intended to provide an opportunity for future hearing on the financial qualifications issue wherein the contentions of the Municipals relating to the legal validity of the applicant's financial arrangements could be heard. On August 24, 1970, the Massachusetts Municipals filed with the Commission a Notice of Withdrawal from the Maine Yankee proceeding. On September 12, the applicant filed a motion asking the Commission to refer to the Director of Regulation the matter of necessary future action in regard to the financial qualification determination. On October 14, the Commission approved the withdrawal of the Massachusetts Municipals; and authorized the Director of Regulation to make appropriate findings with respect to the applicant's financial qualifications to design and construct the facility.

Judicial Review

Antitrust Issues

On February 10, 1970, the U.S. Court of Appeals for the District of Columbia Circuit affirmed the Commission's holding that the Easton Utilities Commission's petition to intervene in the Peach Bottom, Pa. (Peach Bottom Atomic Power Station Units 2 and 3) licensing proceeding [9] was untimely and, accordingly, that Easton was not entitled to obtain judicial review of the Commission's licensing action.

Environmental Matters

Palisades Plant. Intervenors in the Palisades operating license proceeding instituted court actions in the U.S. Court of Appeals for the District of Columbia Circuit and the Federal District Court for the Northern District of Illinois. In each of these court actions, the intervenors sought to enjoin the further conduct of the Palisades proceeding on the ground that the Commission is acting unlawfully, primarily

---

[9] See pp. 124–125, "Annual Report to Congress for 1968" and p. 139, "Annual Report to Congress for 1969."

because of rulings made by the presiding ASLB excluding consideration of the thermal effects question in the proceeding.

The U.S. Court of Appeals for the District of Columbia Circuit denied, on July 20, the intervenors' request for a temporary stay of the Palisades proceeding on the ground that no final order had been entered in the proceeding. On September 2, the court ordered, without opinion, that the petition for review be dismissed as premature.

On August 18, the Illinois Federal District Court denied the intervenors' motion for a temporary restraining order. On August 24, the U.S. Court of Appeals for the Seventh Circuit affirmed the action of the district court on the ground that there is a full and orderly statutory procedure for judicial review of final orders of the Commission, and there is no reason in the proceeding for deviating from the well-established rule that administrative procedures be exhausted prior to judicial intervention.

Shoreham Station. An intervenor in the pending Shoreham (Shoreham Nuclear Power Station Unit No. 1) reactor construction permit proceeding filed suit in the Federal District Court for the Eastern District of New York seeking a judicial declaration of the AEC's responsibilities for implementation of the National Environmental Policy Act of 1969 in the Shoreham proceeding. The suit is still pending.

Davis-Besse Project. On October 20, 1970, the Sierra Club and an Ohio environmental group filed suit in the U.S. District Court for the Northern District of Ohio against Secretary of the Interior Hickel, Dr. Peter A. Morris of the AEC, the Toledo Edison Co. and the Cleveland Electric Illuminating Co. The utility codefendants are applicants for a permit to construct the proposed Davis-Besse Nuclear Power Station (Oak Harbor, Ohio). Among other things, the complaint asks the court for an order which would restrain the AEC from holding hearings on the issuance of a construction permit, and which would order the AEC to revoke the limited construction exemption previously extended by the AEC to the two utilities. The suit is still pending.

Calvert Cliffs Plant. On November 25, 1970, the Calvert Cliffs' Coordinating Committee, Inc., and other organizations filed, in the U.S. Court of Appeals for the District of Columbia Circuit, a petition for review which, generally, concerns petitioners' requests for AEC actions regarding the Calvert Cliffs Nuclear Power Plant in eastern Maryland. The petition, among other things, asks the court to direct the AEC to immediately issue an order to show cause why construction at the Calvert Cliffs plant should not be suspended pending determination of all relevant environmental issues. The AEC had issued permits to the Baltimore Gas & Electric Co., to build two pressurized water reactors at the Calvert Cliffs site on July 2, 1969.[10] The suit is still pending. On December 7, 1970, the same petitioners in the November 25 suit referred to above filed, in the U.S. Court of Appeals for the District of Columbia Circuit, a petition for review of certain portions of the AEC regulations implementing the National Environmental Policy Act which were published in the *Federal Register* on December 4, 1970. The suit is still pending.

---

[10] See pp. 138–139, "Annual Report to Congress for 1969."

APPENDIX 1

ORGANIZATION AND PRINCIPAL STAFF OF U.S. ATOMIC ENERGY COMMISSION [1]

Chairman	Glenn T. Seaborg
Special Assistant	Julius H. Rubin
Commissioner	James T. Ramey
Special Assistant	Alex G. Fremling
Commissioner	Wilfrid E. Johnson
Special Assistant	Lawrence F. O'Donnell
Commissioner	Clarence E. Larson
Special Assistant	John A. Griffin
(Vacancy)	
Secretary of the Commission	W. B. McCool
Controller	John P. Abbadessa
General Counsel	Joseph F. Hennessy
Director, Division of Inspection	Jon D. Anderson
Director of Safeguards and Materials Management	Delmar L. Crowson
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 AND PROMOTIONAL FUNCTIONS

General Manager	Robert E. Hollingsworth
Executive Assistant to the General Manager	Donald C. Kull
Special Assistant to the General Manager	John C. Ryan
Assistant to the General Manager	Harry S. Traynor
Assistant for Equal Employment Opportunity Programs	Marion A. Bowden
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
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
Director, Division of Waste & Scrap Management	Henry A. Nowak
Assistant General Manager for Research and Development	Spofford G. English
Director, Division of Biology and Medicine	John R. Totter
Director, Division of Nuclear Education and Training	Elliot S. Pierce
Director, Division of Research	Paul W. McDaniel

[1] 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 the personnel are 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. NW.).

Assistant General Manager for Development and Production	GEORGE F. QUINN
Director, Division of Isotopes Development	E. EUGENE FOWLER
Director, Division of Peaceful Nuclear Explosives	JOHN S. KELLY
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 Management Information and Telecommunications Systems	M. H. SCHWARTZ
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 Plans	JOHN J. FLAHERTY
Director, Division of Plans and Reports	WILLIAM H. SLATON
Director, Division of Operations Analysis & Forecasting	PAUL C. FINE
Director, Division of Program Analysis	ROGER W. A. LEGASSIE
Assistant General Manager for Military Application and Director, Division of Military Application	Maj. Gen. EDWARD B. GILLER, USAF
Director, Office of Environmental Affairs	JOSEPH J. DINUNNO

Addresses and Managers of Field Offices

Albuquerque Operations Office P.O. Box 5400 Albuquerque, N. Mex. 87115	HAROLD C. DONNELLY
Amarillo Area Office P.O. Box 1086 Amarillo, Tex. 79105	J. DURWOOD YATES
Burlington Area Office P.O. Box 561 Burlington, Iowa 52602	ELBERT W. GILES
Dayton Area Office P.O. Box 66 Miamisburg, Ohio 45342	DARVIN D. DAVIS
Kansas City Area Office P.O. Box 202 Kansas City, Mo. 64141	BILLY W. COLSTON
Los Alamos Area Office Los Alamos, N. Mex. 87544	H. JACK BLACKWELL
Pinellas Area Office P.O. Box 11500 St. Petersburg, Fla. 33733	WALTER C. YOUNGS, JR.
Rocky Flats Area Office P.O. Box 928 Golden, Colo. 80402	FRANK E. ABBOTT
Sandia Area Office P.O. Box 5400 Albuquerque, N. Mex. 77115	LADDIE W. OTOSKI

Chicago Operations Office — KENNETH A. DUNBAR
9800 South Cass Avenue
Argonne, Ill. 60439

200-Bev. Accelerator Facility Office — KENNEDY C. BROOKS
P.O. Box 500
Batavia, Ill. 60510

Grand Junction Office — ALLAN E. JONES
Grand Junction, Colo. 81502

Idaho Operations Office — WILLIAM L. GINKEL
P.O. Box 2108
Idaho Falls, Idaho 83401

Nevada Operations Office — ROBERT E. MILLER
P.O. Box 14100
Las Vegas, Nev. 89114

New York Operations Office — WESLEY M. JOHNSON
376 Hudson Street
New York, N.Y. 10014

Health and Safety Laboratory — JOHN H. HARLEY
376 Hudson Street
New York, N.Y. 10014

Brookhaven Area Office [2] — LYMAN BRYAN
Upton, Long Island, N.Y. 11973

Oak Ridge Operations Office — S. R. SAPIRIE
P.O. Box E
Oak Ridge, Tenn. 37830

Cincinnati Area Office — CLARENCE L. KARL
P.O. Box 39188
Cincinnati, Ohio 45239

New Brunswick Laboratory [3] — EDMUND S. RODSZKOWSKI (Acting)
P.O. Box 150
New Brunswick, N.J. 08901

Paducah Area Office — BERNARD N. STILLER
P.O. Box 1213
Paducah, Ky. 42002

Portsmouth Area Office — ROY V. ANDERSON
Piketon, Ohio 45661

Puerto Rico Area Office — J. PERRY MORGAN
P.O. Box BB
Hato Rey, Puerto Rico 00919

Pittsburgh Naval Reactors Office — LAWTON D. GEIGER
P.O. Box 109
West Mifflin, Pa. 15122

Richland Operations Office — DONALD G. WILLIAMS
P.O. Box 550
Richland, Wash. 99352

---

[2] On July 1, 1970, the former Brookhaven office was consolidated with the New York Operations Office; the organization reverted to an area office status to perform onsite contract administration. Emery L. Van Horn, in charge of the Brookhaven office since 1948, retired on June 30.

[3] On Oct. 20, 1970, the AEC announced the redesignation of the New Brunswick Area Office to New Brunswick Laboratory to better reflect the organization's current mission. Clement J. Rodden who had been director of the facility for 21 years retired in November.

412-406—71——19

San Francisco Operations Office 2111 Bancroft Way Berkeley, Calif. 94704	ELLISON C. SHUTE
Palo Alto Area Office P.O. Box 2370 Stanford, Calif. 94305	HOWARD C. HOOPER
Savannah River Operations Office P.O. Box A Aiken, S.C. 29802	NATHANIEL STETSON
Schenectady Naval Reactors Office P.O. Box 1069 Schenectady, N.Y. 12301	ROBERT P. FASULO

AEC Scientific Representatives[4] Abroad

Bombay, India	HAROLD F. MCDUFFIE
Brussels, Belgium	R. GLENN BRADLEY, *Senior Representative*
Buenos Aires, Argentina	ROBERT H. GOECKERMANN
London, England	WILLIAM L. R. RICE
Paris, France	JOSEPH D. LAFLEUR, JR.
Rio de Janeiro, Brazil	ROBERT H. WILCOX
Tokyo, Japan	GERARD F. HELFRICH

LICENSING AND REGULATORY FUNCTIONS

Director of Regulation	HAROLD L. PRICE
Deputy Director of Regulation	CLIFFORD K. BECK
Assistant Director of Regulation for Reactors	MARVIN M. MANN
Assistant Director of Regulation for Administration	C. L. HENDERSON
Technical Advisor to Director of Regulation	STEPHEN H. HANAUER
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	LYALL E. JOHNSON (Acting)
Director, Division of State and Licensee Relations	EBER R. PRICE
Director, Division of Nuclear Materials Safeguards	CHARLES D. W. THORNTON

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 St. NW. Atlanta, Ga. 30303	JOHN G. DAVIS
Region III (Chicago) 799 Roosevelt Road Glen Ellyn, Ill. 60137	BOYCE H. GRIER
Region IV (Denver) 10395 W. Colfax Denver, Colo. 80215	JOHN W. FLORA
Region V (San Francisco) 2111 Bancroft Way Berkeley, Calif. 94704	RICHARD W. SMITH

[4] The AEC's Chalk River office, Ontario, Canada, was closed as of June 30, 1970. Liaison with Atomic Energy of Canada, Ltd., is now maintained directly from the AEC's Division of International Affairs, Germantown, Md., headquarters.

Addresses and Directors of Nuclear Materials Safeguards District Offices

District I (New York) .... WALTER G. MARTIN
970 Broad Street
Newark, N.J. 07102

District II (Oak Ridge) .... WILLIAM B. KENNA
P.O. Box E
Oak Ridge, Tenn. 37830

District III (San Francisco) .... VINCENT N. RIZZOLO
2111 Bancroft Way
Berkeley, Calif. 94704

APPENDIX 2

MEMBERSHIP OF COMMITTEES, ETC., DURING 1970

STATUTORY COMMITTEES AND BOARDS

Joint Committee on Atomic Energy—91st Congress (Second 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 1970, 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 Departent 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. JOHN G. APPEL, United States Army
RAdm. PHILIP A. BESHANY, United States Navy
Col. (B. Gen. selectee) CHARLES D. DANIELS, Jr., United States Army
Capt. JAMES G. WHITEAKER, United States Navy
Maj. Gen. HENRY B. KUCHEMAN, Jr., United States Air Force
Brig. Gen. EDMUND B. EDWARDS, United States Air Force

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. ROLF ELIASSEN, Environmental Engineer, Stanford University, Palo Alto, Calif.
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, retired (formerly Assistant Director, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.), Santa Fe, N. Mex.
Dr. NORMAN F. RAMSEY, Professor of Physics, Lyman Laboratory of Physics, Harvard University, Cambridge, Mass.
LOMBARD SQUIRES, retired (formerly Assistant General Manager, Explosives Dept. E. I. du Pont de Nemours & Co., Wilmington, Del.), Consultant (Chemical Eng.), Naples, Fla.
WILLIAM WEBSTER, Chairman, New England Electric System, Boston, Mass.
Vacancy
Dr. MELVIN A. HARRISON, *Scientific Officer;* Lawrence Radiation Laboratory, Livermore, Calif.
ANTHONY A. TOMEI, *Executive Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee met four times in 1970: at Savannah River, S.C., on February 25–27; in Washington, D.C., on May 4–6 and November 9–11; and at Livermore, Calif., on July 20–22.

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 in executive session at Washington, D.C., on January 21; a decision was rendered on March 18 on Hobbs Dockets Nos. 22 and 23.

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. JOSEPH M. HENDRIE, *Chairman;* Associate Head, Engineering Division, Department of Applied Science, Brookhaven National Laboratory, Upton, Long Island, N.Y.
Dr. SPENCER H. BUSH, *Vice Chairman;* Senior Staff Consultant, 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, Berkeley, Calif.
HAROLD G. MANGELSDORF, Chairman of the Board, Crown Central Petroleum Corp., Short Hills, N.J.
Dr. HARRY O. MONSON, Senior Engineer, Office of the Director, Argonne National Laboratory, Argonne, Ill.
Dr. ARLIE A. O'KELLY, Consultant (Industrial Chemistry), Littleton, Colo.
Dr. DAVID OKRENT, Visiting Professor of Nuclear Engineering, University of Arizona, Tucson, Ariz.
Dean NUNZIO J. PALLADINO, College of Engineering, The Pennsylvania State University, University Park, Pa.
Dr. CHESTER P. SIESS, Professor of Civil Engineering, University of Illinois, Urbana, Ill.
LOMBARD SQUIRES, retired (formerly Assistant General Manager, Explosives Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.), Consultant (Chemical Engineering), Naples, Fla.
Dr. WILLIAM R. STRATTON, Physicist, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

The committee met 13 times in 1970, at Washington, D.C.: January 8–10, January 23–24, February 5–7, March 5–7, April 9–11, May 7–9, June 11–13, July 9–11, August 13–15, September 17–19, October 15–17, November 12–14, and December 10–12.

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 and alternates qualified in the conduct of administrative proceedings 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, Attorney-at-law, Washington, D.C.

R. B. BRIGGS, Associate 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 & Olmsted, Santa Fe, N. Mex.
VALENTINE B. DEALE, Attorney-at-law, Washington, D.C.
Dr. RICHARD L. DOAN, Tucson, Ariz.
Dr. STUART G. FORBES, TRW Systems, Redondo Beach, Calif.
Dr. JOHN C. GEYER, Chairman, Department of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, Md.
JAMES P. GLEASON, Attorney-at-law, Washington, D.C.
Dr. CLARK GOODMAN, Professor of Physics, 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.
Dr. WALTER H. JORDAN, Senior Research Adviser, Oak Ridge National Laboratory, Oak Ridge, Tenn.
ROBERT M. LAZO, Partner, Law Firm of Fidler, Bradley, Patnaude and Lazo, Chicago, Ill.
ARTHUR W. MURPHY, Columbia University School of Law, New York City
WARREN E. NYER, Vice President, Idaho Nuclear Corporation, Idaho Falls, Idaho
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.
WALTER T. SKALLERUP, Jr., Partner in law firm of Cox, Langford & Brown, Washington, D.C.
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, Professor Emeritus, Sanitary Engineering, The Johns Hopkins University, Baltimore, Md.
HOOD WORTHINGTON, retired, E. I. du Pont de Nemours & Co. Scientist and Administrator, Wilmington, Del.
Dr. IRA F. ZARTMAN, Annapolis, Md.
JAMES R. YORE, *Panel Executive Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

Fifteen new boards were drawn from the panel in 1970 for regulatory proceedings. A general panel meeting was held with the AEC Commissioners on April 14–15, 1970, at Airlie House, Va., and several 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 composed 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. During 1970, Dr. Lawrence R. Quarles served as the third member. The board reviewed 10 proceedings during 1970.

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 primarily 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 and assesses liquidated damages pursuant to section 104(c) of the Contract Work Hours Standards Act. The revised rules of practice of the board were published in the *Federal Register* on February 12, 1970, and codified as part 3 of title 10, Code of Federal Regulations.

PAUL H. GANTT, *Chairman;* U.S. Atomic Energy Commission, Washington, D.C.
JOHN G. ROBERTS, *Vice Chairman;* U.S. Atomic Energy Commission, 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, Brookhaven National Laboratory, Upton, N.Y.
HENRY B. KEISER, Attorney-at-law and President, Federal Publications, Inc., Washington, D.C.
LEONARD J. KOCH, Office of the Director, Argonne National Laboratory, Argonne, Ill.
JOHN A. MCINTIRE, Consulting Attorney, Office of Judge Advocate General, U.S. Navy, Washington, D.C.
ROBERT S. MOSS, Attorney-at-law,, 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.
JOHN OLIVER, Director of Corporate Development, North American Royalities, Inc., Chattanooga, Tenn.
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.
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.

Eighteen panels were designated to hear, consider, and decide appeals during 1970.

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., Westboro, 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 1970: at Washington, D.C., on June 11 and at Berkeley, Calif., on December 9–10.

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. ROBERT D. MOSELEY, Jr., *Chairman;* Chairman, Dept. of Radiology, University of Chicago, Chicago, Ill.

Dr. PERRY R. STOUT, *Vice-Chairman;* Professor of Soil Sciences & Chemist, Agricultural Exp. Station, University of California, Davis, Calif.

Dr. PHILIP P. COHEN, Professor and Chairman, Department of Physiological Chemistry, University of Wisconsin School of Medicine, Madison, Wis.

Dr. CLEMENT A. FINCH, Professor of Medicine, Division of Hematology, Department of Medicine, University of Washington Medical School, Seattle, Wash.

Dr. ARIE J. HAAGEN-SMIT, Professor of Biology, California Institute of Technology, Pasadena, Calif.

Dr. JOHN S. LAUGHLIN, Chief, Division of Biophysics, Sloan-Kettering Institute for Cancer Research, New York, N.Y.

Dr. WILLIAM J. SCHULL, Professor, Department of Human Genetics, University of Michigan, Ann Arbor, Mich.

Dr. JOHN B. STORER, *Scientific Secretary;* Scientific Director for Pathology and Immunology, Oak Ridge National Laboratory, Oak Ridge, Tenn.

ROSEMARY ELMO, *Executive Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee met five times in 1970; at Washington, D.C., January 9–10, March 13–14, and September 11–12; Richland, Wash., May 7–8; Los Alamos, N. Mex., November 13–14.

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 during 1970: at the National Reactor Testing Station, Idaho, on July 7–9.

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 applications of radioisotopes and radiation, and private production and distribution of radioisotopes.

Dr. IRA LON MORGAN, *Chairman;* Director, Center for Nuclear Studies, University of Texas, Austin, Tex.

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, Radiation Laboratory, University of Notre Dame, Notre Dame, Ind.

Dr. MERRIL EISENBUD, Director of Laboratory for Environmental Studies, New York University, New York, N.Y.

Dr. BERNARD A. FRIES, Senior Research Associate, Chevron Research Co., Richmond, Calif.

Dr. VINCENT P. GUINN, Professor of Chemistry, University of California, Irvine, Calif.

BERNARD MANOWITZ, Head, Radiation Division, Brookhaven National Laboratory, Upton, Long Island, N.Y.

LYLE E. PACKARD, President, Packard Instrument Co., Inc., Chicago, Ill.

Dr. A. J. RESTAINO, Manager, Polymer Section, Chemical Research Department, Atlas Chemical Industries, Inc., Wilmington, Del.

Dr. SEYMOUR ROTHCHILD, Consultant, Brookline, Mass.

EDWIN A. WIGGIN, Manager, Technical Projects, Atomic Industrial Forum, New York, N.Y.

The committee met once in 1970: at AEC Headquarters, Germantown, Md., on November 5–6.

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 radiosotopes in humans.

LYALL E. JOHNSON, *Acting Chairman;* Acting 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, Professor of Radiology, University of Pennsylvania, School of Medicine, Philadelphia, Pa.

Dr. GEORGE V. LEROY, Director, University Health Services, University of Chicago, Chicago, Ill.

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 1970: at Washington, D.C., on March 14.

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.

DELMAR L. CROWSON, *Vice Chairman;* Director, Office of Safeguards and Materials Management, U.S. Atomic Energy Commission, Washington, D.C.

Dr. CHARLES D. W. THORNTON, *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 H. HALL, retired (formerly Assistant Director, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.), Santa Fe, N. Mex.

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. FRED H. TINGEY, Manager of Operations Analysis, 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., Professor of Applied Mathematics and Physics, Howard University, Washington, D.C.

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., Private Consultant, McLean, Va.

Dr. MANSON BENEDICT, Head, Nuclear Engineering Dept., Massachusetts Institute of Technology, Cambridge, Mass.

The committee held two meetings during 1970: at Germantown, Md., June 9–10, and Washington, D.C., December 9–10.

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. CARL A. ANDERSON, Jr., Manager, Advanced Reactors Division, Westinghouse Electric Corp., Madison, Pa.

Dr. ROBERT AVERY, Director, Applied Physics Division, Argonne National Laboratory, Argonne, Ill.

Dr. ROBERT T. BAYARD, Westinghouse Electric Corp., Bettis Atomic Power Laboratory, West Mifflin, Pa.

DESLONDE R. DEBOISBLANC, EBASCO Services, Inc., New York, N.Y.

Dr. GERHARD DESSAUER, Director, Physics Section, Savannah River Laboratory, E. I. du Pont 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. PETER L. HOFMANN, Manager, Reactor and Plant Technology Department, WADCO Corp., Hanford Engineering Development Laboratory, Richland, Wash.

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. SOL PEARLSTEIN, Director, National Neutron Cross Section Center, Brookhaven National Laboratory, Upton, Long Island, N.Y.

Dr. THOMA M. SNYDER, Consultant, 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 three times during 1970: At AEC Headquarters, January 14–15; at Fayetteville, Ark., May 4–6; and Los Alamos Scientific Laboratory, N. Mex., November 4–5.

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 recomendations with respect to the classification rules and guides for the control of scientific and technical information.

Dr. WARREN C. JOHNSON, *Chairman;* Vice President Emeritus and Professor Emeritus, Dept. of Chemistry, University of Chicago, Chicago, Ill.
Dr. EUGENE EYSTER, 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 Special Projects, Lawrence Radiation Laboratory, Livermore, Calif.
PAUL R. VANSTRUM, Vice President, Union Carbide Corp., Nuclear Division, Oak, Ridge, Tenn.

The committee met three times in 1970: at Las Vegas, Nev., January 12–14; at Albuquerque and Los Alamos, N. Mex., June 1–4; and at Las Vegas, Nev., October 26–27. In addition, the committee made an orientation trip during the year to Sandia Laboratory, Albuquerque, N. Mex. A subcommittee of the full committee met with the Isotope Separation Subcommittee of the Advisory Committee on Safeguards on March 23, at Oak Ridge, Tenn., and on July 27, at Washington, D.C.

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 insure 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. ROY W. GOULD, *Chairman;* Assistant Director (for Controlled Thermonuclear Research), Division of Research, U.S. Atomic Energy Commission, Washington, D.C.
Dr. SOLOMON J. BUCHSBAUM, Sandia Corp., Albuquerque, N. Mex.
Dr. H. R. CRANE, University of Michigan, Ann Arbor, Mich.
Dr. T. KENNETH FOWLER, Lawrence Radiation Laboratory, Livermore, Calif.
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. JOHN R. WHINNERY, University of California, Berkeley, Calif.

The committee met three times during 1970: at the Lawrence Radiation Laboratory, Livermore, Calif., May 25–26; at Princeton, N.J., July 22–23; and at Washington, D.C., October 7–8.

High Energy Physics Advisory Panel

The High Energy Physics Advisory Panel was established in January 1967 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, Long Island, N.Y.

Dr. BRUCE CORK, Argonne National Laboratory, Argonne, Ill.
Dr. EMANUEL R. PIORE, International Business Machines Corp., New York, N.Y.
Prof. JEROME L. ROSEN, University of Rochester, Rochester, N.Y.
Dr. JAMES R. SANFORD, National Accelerator Laboratory, Batavia, Ill.
Dr. ANDREW M. SESSLER, Lawrence Radiation Laboratory, Berkeley, Calif.
Prof. GEORGE A. SNOW, University of Maryland, College Park, Md.
Dr. GERALD F. TAPE, Associated Universities, Inc., Washington, D.C.
Prof. KENT M. TERWILLIGER, University of Michigan, Ann Arbor, Mich.
Prof. SAM B. TREIMAN, Princeton University, Princeton, N.J.
Dr. WILLIAM A. WENZEL, Lawrence Radiation Laboratory, Berkeley, Calif.
Prof. WILLIAM J. WILLIS, Yale University, New Haven, Conn.
Dr. BURTON RICHTER, Stanford Linear Accelerator Center, Palo Alto, Calif.
Dr. BERNARD HILDEBRAND, *Executive Secretary;* University Research Branch, High Energy Physics Programs, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

The panel met six times during 1970: at Washington, D.C., January 12–13, July 17–18, May 24–25, and December 4–5; at the Lawrence Radiation Laboratory, Berkeley, Calif., April 17–18; and at the National Accelerator Laboratory, Batavia, Ill., October 11–12.

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, Long Island, N.Y.
Dr. MARIO L. JUNCOSA, The Rand Corp., Santa Monica, Calif.
Prof. FREDERICK P. BROOKS, University of North Carolina, Chapel Hill, N.C.
Prof. GERALD ESTRIN, Department of Engineering, University of California at Los Angeles, Calif.
Dr. SIDNEY FERNBACH, Computation Division, Lawrence Radiation Laboratory, University of California, Livermore, Calif.
Dr. J. WALLACE GIVENS, Jr., Applied Mathematics Division, Argonne National Laboratory, Argonne, Ill.
Dr. PAUL R. GARABEDIAN, AEC Computing and Applied Mathematics Center, Courant Institute of Mathematical Sciences, New York University, N.Y.
Dr. ALSTON S. HOUSEHOLDER, University of Tennessee, Knoxville, Tenn.
Dr. JOHN R. PASTA, Office of Computer Activities, National Science Foundation, Washington, D.C.
Dr. ROGER LAZARUS, *Secretary;* Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

The committee met twice during 1970: at Washington, D.C., on April 30–May 1 and December 10–11.

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, Manager, Nuclear Technology, Idaho Nuclear Corp., Idaho Falls, Idaho.
Dr. FRANK FEINER, Knolls Atomic Power Laboratory, Schenectady, N.Y.
Dr. W. F. GOOD, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Prof. HERBERT GOLDSTEIN, Columbia University, New York, N.Y.
Dr. MALVIN H. KALOS, Courant Institute of Mathematical Sciences, New York University, New York, N.Y.
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. LEE NORTHCLIFFE, Texas A. & M. University, College Station, Tex.
Dr. GEORGE L. ROGOSA, Chief, Physics Branch, P&M Programs, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.
Dr. ROBERT E. CHRIEN, *Secretary;* Brookhaven National Laboratory, Upton, Long Island, N.Y.

The committee met twice in 1970: at Argonne, Ill., May 20–22; at Livermore, Calif., December 1–3.

Personnel Security Review Board

The Personnel Security Review Board was established 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 a recommendation to the General Manager on two cases during 1970.

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 1970: at Los Alamos Scientific Laboratory, N. Mex., on June 17–18.

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.
LEONIDE 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 met once in 1970: First at Pittsburgh, Pa., then continued the meeting at Oak Ridge, Tenn., on June 3–5.

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., Stanford Linear Accelerator Center, Stanford University, Palo Alto, Calif.
HARRY P. PEARSON, Director, Information and Publications, Idaho Nuclear Corp., Idaho Falls, Idaho.
DENNIS PULESTON, Head, Information Division, Brookhaven National Laboratory, Upton, L.I., N.Y.
WAYNE A. SNYDER, Manager, Technical Information, Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Wash.
A. VIRGINIA STERNBERG, Supervisor, Bettis Technical Information, Westinghouse Electric Corp., West Mifflin, Pa.
Dr. STUART STURGES, Manager, Technical Information, Knolls Atomic Power Laboratory, Schenectady, N.Y.
CHARLES D. TABOR, General Manager, Technical Division, Goodyear Atomic Corp., Piketon, Ohio.
JOSEPH W. VOTAW, Assistant to the 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 1970: at Oak Ridge, Tenn., on December 1–2.

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. R. V. LANEY
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	W. H. HAMILTON
Manager, Operations	E. J. KREH
Manager, Operating Plants	G. W. HARDIGG

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. R. RONALD RAU

Associated Universities, Inc. [2]

Chairman, Board of Trustees	Dr. A. W. KIMBALL
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

---

[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 Appendix 1 of the supplementary report, "Fundamental Nuclear Energy Research—1970."

[2] Associations or groups of educational institutions participating in AEC facility operations or programs are listed in Appendix 1 of the supplementary report, "Fundamental Nuclear Energy Research—1970."

Administrative Division Manager	R. S. RAMSEY
Engineering Division Manager	M. H. WEGENER
Manufacturing Division Manager	C. R. POOLE
Mechanical Division Manager	L. W. HALE
Quality Division Manager	R. L. HOLMBERG

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 PRODUCTION CENTER (National Lead Co. of Ohio, contractor), Fernald, Ohio

Manager	M. S. NELSON
Assistant Manager	C. R. CHAPMAN

HANFORD FACILITIES (nine 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, and WADCO), 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 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 Engineering Development Laboratory [3] (WADCO Corp., a wholly owned subsidiary of Westinghouse Electric Corp., contractor), Richland, Wash.

President	Dr. W. H. ESSELMAN
Vice President and Technical Director	Dr. BERTRAM WOLFE
Controller	N. STOUGH

[3] To meet requirements of the 1969 Federal Tax Reform Act as it applies to nonprofit public foundations, Battelle Memorial Institute requested the AEC, on Jan. 30, 1970, to relieve it of the management responsibility for certain reactor development activities being conducted by Battelle at, or by, the Pacific Northwest Laboratory. The AEC transferred responsibility for all Fast Flux Test Facility (FFTF) and liquid metal fast breeder reactor programs and part of the remaining reactor development programs being conducted at the Pacific Northwest Laboratory (PNL) to Westinghouse Electric Corp. on July 1, 1970. Westinghouse (through its Advanced Reactor Division, Pittsburgh, Pa.) previously had only the design responsibility for the plant. Battelle will continue to be the contract-operator of the Pacific Northwest Laboratory for nonreactor-related studies in such areas of research as life and physical sciences, environmental studies, radioactive waste management, isotopes development, plutonium utilization, space propulsion systems, reactor safety, and certain types of reactor studies not associated with the FFTF. On July 1, 1970, the work was transferred to the Westinghouse Electric Corp which had formed the subsidiary WADCO Corp. to perform the AEC work. The "Hanford Engineering Development Laboratory" was established to provide a separate management organization to differentiate the WADCO work from that done by Battelle at the PNL. On July 1, some 1000 Battelle employees were also transferred to WADCO.

***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.

President	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
Manager, Operations and Services Division	William D. Richmond
Manager, Finance and Administration Division	Wallace Sale
Manager, Sponsor Development and Legal Division	Sam J. Farmer
Manager, Chemistry and Metallurgy Division	Dr. Don R. de Halas
Manager, Environmental and Life Sciences Division	Dr. Edward L. Alpen
Manager, Physics and Engineering Division	Frank G. Dawson
Manager, Systems and Electronics Division	Eugene R. Astley

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, S7G Project	E. C. Rumbaugh
Manager, Operating Nuclear Plants	D. J. Anthony
Manager, S6G Project	D. D. Adams

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. James L. Born
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:

Advanced Studies	Dr. ARTHUR T. BIEHL
Biomedical Research and Chemistry	Dr. ROGER E. BATZEL
Controlled Thermonuclear Research	Dr. T. KENNETH FOWLER
Military Applications	Dr. CHARLES A. McDONALD
Nuclear Design	Dr. HARRY A. REYNOLDS
Nuclear Testing	Dr. JAMES E. CAROTHERS
Physics	Dr. WILLIAM WENZEL
Plans	A. CARL HAUSSMANN
Plowshare	Dr. GLENN C. WERTH
Special Projects	Dr. JACK W. ROSENGREN
Support	DUANE C. SEWELL

LIQUID METAL ENGINEERING CENTER (Atomics International, Division of North American Rockwell Corp., contractor), Canoga Park, Calif.

Division Director	R. W. DICKINSON
Manager, Engineering	O. J. FOUST
Manager, Operations	J. E. OWENS

LOS ALAMOS SCIENTIFIC LABORATORY (University of California, contractor), Los Alamos, N. Mex.

Director	Dr. HAROLD M. AGNEW
Technical Associate Director	Dr. RAEMER E. SCHREIBER
Assistant Director, Security and Legal Liaison	PHILLIP F. BELCHER
Assistant Director, Financial Planning	LESLIE G. HAWKINS
Assistant Director, Administration	HENRY R. HOYT
Assistant Director, Weapons	Dr. DUNCAN P. MACDOUGALL

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
Manager, Idaho Administrative Operations	DONALD F. WOOD
Deputy Director, Applied Physics Division	FRED 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	D. H. KRUEGER
Manager, S5G Plant	C. T. WILLIAMSON
Manager, Site Administration Services	R. L. JORDAN

Idaho Nuclear Corp. (Jointly owned subsidiary of Aerojet General Corp., Allied Chemical Corp., and Phillips Petroleum Co.), Idaho Falls

President and General Manager — C. M. RICE
Vice President — W. E. NYER
Vice President for Chemical Operations and Waste Management — F. H. ANDERSON
Assistant General Manager—Research and Engineering — J. W. MORFITT
Assistant General Manager, Site Operations — J. P. LYON

Westinghouse Electric Corp., Idaho Falls

Manager, Naval Reactor Facility — H. D. RUPPEL
Assistant to Manager, NRF — M. W. WALCHER
Manager, Administrative Services — W. H. WALKER
Manager, Naval Reactors Facility Training — 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 — W. J. O'BRYANT
Manager, Quality Control — C. WILLIAMS
Manager, Radiation Engineering — C. S. ABRAMS
Controller, Naval Reactors Facility — J. W. STOPPER

NEVADA TEST SITE (Reynolds Electrical & Engineering Co., contractor), Mercury, Nev.

Executive Vice President — F. I. STRABALA
Vice President—Operations — R. W. KIEHN
Vice President—Programs — H. D. CUNNINGHAM
Vice President—General Counsel — K. C. EFROYMSON
Manager, Material Division — H. E. DEARMAN
Manager, Administration Division — R. E. GILLETT
Manager, Technical Services Division — V. M. MILLIGAN
Manager, Field Operations Division — H. RUNNELS
Manager, Equipment-Maintenance Division — F. J. SOLAEGUI

NUCLEAR ROCKET DEVELOPMENT STATION (Los Alamos Scientific Laboratory, Pan American World Airways, Inc., Westinghouse Electric Corp., contractors), 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 — FLOYD L. CULLER
Associate Director — F. R. BRUCE
Associate Director — DONALD B. TRAUGER
Associate Director — A. H. SNELL
Associate Director — J. L. LIVERMAN
Associate Director — M. E. RAMSEY

PANTEX PLANT (Mason & Haunger-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. D. TABOR
Deputy General Manager	N. H. HURT

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. FRED C. SHOEMAKER

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, Theöretical 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
Manufacturing Manager	HERBERT E. BOWMAN
Controller	CLEMENT H. DOMPIERRE
Quality Manager	JOHN G. EPP
Environment Control Manager	WILLIAM H. LEE
Personnel and Services Manager	EDWARD J. WALKO
Director of Research and Development	Dr. JAMES F. WILLGING

SANDIA LABORATORIES (Sandia Corp., contractor), facilities at Sandia Base, Albuquerque, N. Mex.; Livermore, Calif.; and Tonopah, Nev.

President	Dr. 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	Dr. T. B. COOK, Jr.
Vice President	RICHARD PARTRIDGE
Vice President	R. A. BICE
Vice President	Dr. 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 Plant

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. PINDAR
Associate Director, Administrative Services Division	ROBERT H. MOULTON, Jr.

APPENDIX 4

RULES AND REGULATIONS

The AEC's regulations are contained in title 10, chapter 1 of the Code of Federal Regulations. Effective and proposed regulations concerning licensed activities and published in the *Federal Register* during 1970 are set forth below.

REGULATIONS AND AMENDMENTS PUT INTO EFFECT

Corrections of Citations of Authority

Amendments to 10 CFR chapter 1, correcting citations of authority and making minor editorial corrections, were published on July 17, 1970, effective immediately.

Public Disclosure—Part 2

On May 16, 1970, an amendment of part 2 ("Rules of Practice") was published, effective June 15, 1970, which provides that correspondence or reports between licensees or applicants and the AEC regarding special nuclear material safeguards and detailed physical security measures for licensed production and utilization facilities are subject to public disclosure only in accordance with the provisions § 9.10 of part 9.

Subpoena of AEC Personnel and Production of AEC Documents—Part 2

On December 23, 1970, amendments to part 2 were published, effective immediately which clarified AEC policy and revised the procedures with respect to subpoena of AEC personnel and the production of Commission inspection reports and internal working papers in Commission adjudicatory proceedings.

An amendment to § 2.720, Subpoenas, dealing with the appearance of AEC personnel to give oral testimony, provides that AEC staff witnesses designated by the General Manager or the Director of Regulation, as appropriate, or their designees, will be made available for oral examination at the hearing or on deposition regarding any matter, not privileged, which is relevant to the issues in the proceeding. The attendance and testimony of the Commissioners and named AEC personnel at a hearing or on deposition may not be required by the presiding officer, by subpoena or otherwise, although in exceptional circumstances, the matter of whether the attendance and testimony of named AEC personnel should be required may be certified to the Commission for determination.

Section 2.720 was also amended to provide that production of records or documents in the custody of the Commissioners and AEC employees will be dealt with under a new § 2.744, and that the matter of the production of records or documents in the custody of AEC personnel other than full-time AEC employees, such as advisors and consultants, will be immediately certified by the presiding officer to the Commission for determination.

The new § 2.744 specifies that AEC will as a matter of policy produce, on the application of a party to an adjudicatory proceeding, and a showing of need and relevance, Commission inspection reports and other records and documents, the basic purpose of which is to record matters of fact relating to license applications or licensed activities, if the facts contained in those reports and documents are not otherwise available. Certain specified privileged matter would be deleted from those reports, records and documents. Internal working papers and records and documents of the type specified in § 9.5 of part 9 are treated as privileged and exempt from disclosure. Upon application by a party, requested internal working papers, records and documents, will be produced for the *in camera* inspection of the presiding officer exclusively and only to the extent necessary to determine: (*a*) Need and relevancy, (*b*) whether they are in fact internal working papers or other exempt records or documents, and (*c*) whether their production, if exempt, would nevertheless not be contrary to the public interest and would not adversely affect the rights of any person.

If the General Manager or the Director of Regulation, as appropriate, objects to the production of privileged records and documents in disagreement with the presiding officer, the matter will be certified to the Commission or the Atomic Safety and Licensing Appeal Board, as appropriate for determination.

Backfitting of Nuclear Facilities—Parts 2, 50, 115

On March 31, 1970, amendments of parts 2, 50 ("Licensing of Production and Utilization Facilities"), and 115 ("Procedures for Review of Certain Nuclear Reactors Exempted from Licensing Requirements") were published, effective immediately, which: (*a*) set forth AEC policy concerning imposition of additional safety requirements after issuance of a construction permit, and (*b*) eliminated "provisional" from construction permits and operating licenses.

Implementation of Environmental Legislation—Parts 2, 50

On April 2, 1970, amendments of parts 2 and 50 were published, effective immediately, adding a statement of general policy to part 50 indicating how the AEC would exercise its responsibilities under the National Environmental Policy Act of 1969 (NEPA) regarding the licensing of power reactors and fuel reprocessing plants. A revised general policy statement (appendix D to part 50) was published on December 4, 1970.

"Practical Value" Amendments To Parts 2 and 50

On December 29, 1970, the AEC published amendments to parts 2 and 50 to implement P.L. 91–560, which eliminated from the Atomic Energy Act the requirement for a finding of practical value before licenses under § 103 could be issued; required licensing of facilities for commercial or industrial purposes under § 103; and amended the antitrust provisions of § 105.

The amendments to part 50 require filing of a separate application for an operating license in conjunction with the final safety analysis report. They also provide that in any hearing on antitrust aspects of an application, the Commission, if it finds that the proposed license would create or maintain a situation inconsistent with the antitrust laws, will consider such other factors deemed necessary to protect the public interest, including the need for power in the affected area.

Amendments to part 2 provide procedures for carrying out the Commission's responsibilities concerning antitrust matters, which include obtaining advice and recommendations from the Attorney General, giving public notice, and providing for hearings on antitrust matters where appropriate. These hearings would generally be held separately from hearings on radiological safety and environmental matters. Provision is made for three-man atomic safety and licensing boards and a three-member Atomic Safety and Licensing Appeal Board comprised of one member qualified in the conduct of administrative proceedings and two having such technical or other qualifications as the Commission deems appropriate to the issues to be decided.

High Radiation Areas—Part 20

On March 25, 1970, amendments to part 20 ("Standards for Protection Against Radiation") were published, effective April 24, 1970, which specify additional acceptable methods of controlling access to high radiation areas. Alternatives to these control methods may be submitted by licensees for AEC approval.

Reports of Overexposures—Part 20

On September 29, 1970, an amendment to part 20 was published, effective October 29, 1970, which requires licensees to include in a separate part of the report, submitted under § 20.405(c), for each individual exposed, the name, social security number, and date of birth, and an estimate of the individual's exposure. (Published as proposed rule on June 4, 1970.)

Retention of Radiation Exposure Records—Part 20

On November 29, 1970, an amendment of part 20 was published, effective December 26, which requires licensees to retain indefinitely, or until their disposal is authorized by the Commission: (*a*) The records of external exposure required to be maintained under § 20.401, and (*b*) records of bioassays made pursuant to § 20.108.

Control of Releases of Radioactivity to the Environment—Parts 20, 50

On April 1, 1970, proposed amendments of parts 20 and 50 were published for public comment. The proposed amendments are intended to assure that reasonable efforts are made by licensees to continue to keep exposures to radiation and releases of radioactivity in effluents as low as practicable. The amendments to part 50 would specify design and operating requirements to minimize quantities of radioactivity released in gaseous and liquid effluents from light water cooled nuclear power reactors.

Exempt Concentrations and Generally Licensed Items—Parts 30, 31

On March 3, 1970, amendments to parts 30 ("Rules of General Applicability to Licensing of Byproduct Material") and 31 ("General Licenses for Certain Quantities of Byproduct Material and Byproduct Material Contained in Certain Items") were published, effective April 2, 1970, which added to § 30.70 an exempt concentration value for strontium-85 and revoked the general license in § 31.3(c) for a light meter containing strontium-90.

Exemption of Microwave Receiver Protector Tubes—Part 30

On June 6, 1970, an amendment of part 30 was published, effective upon publication, which exempted from licensing requirements microwave receiver protector tubes containing not more than 150 millicuries of tritium per tube.

Reporting Requirements—Part 32

On April 28, 1970, amendments of part 32 ("Specific Licenses to Manufacture, Distribute or Import Exempted and Generally Licensed Items Containing Byproduct Material"), were published, effective July 1, 1970, which revised the reporting requirements applicable to licensees who import or transfer byproduct material for use under the exemptions from licensing requirements set out in §§ 30.14, 30.15, 30.16, 30.19, and 30.20.

Radiographic Equipment Inspection and Maintenance Programs—Part 34

On November 13, 1970, amendments of part 34 ("Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations") were published, effective December 13, 1970. The changes require licensees doing radiographic work to have programs for the inspection and maintenance of exposure devices and storage containers.

Technetium-99m for Thyroid Scans—Part 35

On April 9, 1970, an amendment to part 35 ("Human Uses of Byproduct Material") was published, effective upon publication, which added to Group II of § 35.100 the use of technetium-99m as pertechnetate for thyroid scans.

Small Quantities of Byproduct Material Exemption—Parts 20, 30, 31, 32, 35

On April 22, 1970, amendments of parts 20, 30, 31, 32 and 35 were published which exempted from licensing small quantities of byproduct material, and certain quantities of byproduct material contained in calibration sources installed in ionizing radiation measuring instruments; revoked a general license in part 31 for similar quantities of byproduct material; and revised appendix C of part 20 to conform quantities listed in appendix C to the exempt quantities. The amendments of parts 20, 30, 32, and 35 became effective on May 22, 1970. The amendment of part 31 was to become effective on October 22, 1970; however, this effective date was extended until determination of a petition for rule making filed by Nuclear Chicago Corp.

Exemption of Piezoelectric Ceramic Containing Source Material—Part 40

On April 18, 1970, the Commission published an amendment of part 40 ("Licensing of Source Material"), effective May 18, 1970, which added to § 40.13 an exemption from licensing requirements for piezoelectric ceramic containing not more than 2 percent by weight source material.

Source Material Reporting—Parts 40, 150

On July 30, 1970, amendments of parts 40 and 150 ("Exemptions and Continued Regulatory Authority in Agreement States Under Section 274") were published which extend safeguards reporting requirements to source material licensees. Requirements include reports of transfers and inventories by persons authorized to possess 1,000 or more kilograms of source material, and any attempts of theft or unlawful diversion.

Exemption for Facilities Proceeding Irradiated Materials Containing Limited Quantities of Special Nuclear Material—Part 50

On April 16, 1970, an amendment of part 50 was published, effective upon publication, which excludes from the definition of "production facility" in part 50, facilities in which processing is conducted pursuant to a license issued under parts 30 and 70, or equivalent regulations of an Agreement State, for the receipt, possession, use, and transfer or irradiated special nuclear material, which authorizes the processing of the irradiated material on a batch basis for the separation of selected fission products and limits the process batch to not more than 15 grams of special nuclear material.

Quality Assurance Criteria—Part 50

On June 27, 1970, amendments to part 50 were published which established quality assurance requirements for the design, construction, and operation of structures, systems and components of nuclear powerplants that are important to safety.

Emergency Plans for Nuclear Facilities—Part 50

On December 24, 1970, amendments of part 50 were published, effective January 23, 1971, which require definitive information on emergency plans from applicants for nuclear facility construction permits and operating licenses.

Criticality Monitoring Requirements—Part 70

On March 18, 1970, an amendment of part 70 ("Special Nuclear Material") was published, effective upon publication, which added a note to § 70.24 which clarifies that underwater monitoring is not required by § 70.24 when special nuclear material is handled and stored beneath water shielding.

New Special Nuclear Material Reporting Forms—Parts 70, 150

Amendments of parts 70 and 150 were published May 16, 1970, effective June 15, 1970, requiring use of new forms for reporting to AEC receipts, transfers, inventories and losses of special nuclear material.

General License for Certain Shipments of Radioactive Material—Part 71

On April 7, 1970, an amendment of part 71 ("Packaging of Radioactive Material for Transport") was published, effective upon publication, which added to the general license in § 71.7 authority for any licensee to use any package which has been specifically licensed for such use by the AEC.

Physical Protection of Special Nuclear Material—Part 73

On December 31, 1969, amendments to part 73 ("Protection of Special Nuclear Material in Transit") were published, effective January 30, 1970, to clarify responsibility for making arrangements for physical protection of special nuclear material while in transit.

On April 18, 1970, amendments were published, effective July 17, 1970, of part 73 to require specified types of physical protection for certain quantities and forms of special nuclear materials while in use or storage.

Recognition of Agreement State Licenses—Part 150

On May 20, 1970, amendments to part 150 were published, effective June 19, 1970, which increased the time during which Agreement State Licensees may engage in similar activities in nonagreement States under § 150.20 to 180 days per year, and made other changes to that section.

License Fees and Backfitting Amendments—Part 170

On April 25, 1970, an amendment to part 170 ("Fees for Facilities and Materials Licenses Under the Atomic Energy Act of 1954, as Amended") was published, effective April 30, 1970, to clarify that the "backfitting" amendments to part 170 published on March 31, 1970 (see "Backfitting of Nuclear Facilities—parts 2, 50, 115" on previous page), do not apply to proceedings for issuance of provisional construction permits or provisional operating licenses for which notices of hearing or proposed issuances were published before March 31, 1970.

PROPOSED REGULATIONS AND AMENDMENTS

Fuel Loading and Low Power Testing—Parts 2, 50

On October 28, 1970, proposed amendments to parts 2 and 50 were published for comments which would: (*a*) Define the extent of preoperational activities, including fuel loading, that may be conducted prior to issuance of an operating license for a power reactor, and (*b*) clarify and codify authorization of consideration by atomic safety and licensing boards of requests for licenses to conduct low power testing while proceedings on issuance of operating licenses are pending.

Civil Penalties—Parts 2, 20, 30, 40, 50, 55, 70, 71, 73 and 150

On December 17, 1970, proposed amendments to part 2 (and proposed conforming amendments to parts 20, 30, 40, 50, 55, 70, 71, 73, and 150), to implement the authority given the AEC to impose civil fines for violations of regulations, the Act, and license conditions were published for public comment.

Revision of License Fee Schedule—Parts 30, 40, 70, 170

On August 4, 1970, proposed amendments of parts 30, 40, 70 and 170 ("Fees for Facilities and Materials Licenses Under the Atomic Energy Act of 1954, as Amended") were published for public comment which would increase license fees charged by the AEC and expand the fee schedules to cover additional material licenses.

Reporting Construction Deficiencies—Parts 50, 115

On July 28, 1970, proposed amendments of parts 50 and 115 were published for public comment which would establish reporting requirements regarding deficiencies in design and construction of nuclear powerplants.

DENIAL OF PETITIONS FOR RULE MAKING

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 from licensing requirements cufflinks of depleted uranium. On July 14, 1970, the Commission published a Notice of Denial of Petition for Reconsideration of the petition for rulemaking.

APPENDIX 5

ANNOUNCED DEFENSE-RELATED UNDERGROUND NUCLEAR DETONATIONS, 1970 [1]

Name	Date	Yield
MANDREL Series (January–June):		
1. Fob	January 23	Less than 20 kilotons (kt.).
2. Ajo	January 30	Less than 20 kt.
3. Grape B	February 4	20 to 200 kt.
4. Labis	February 5	20 to 200 kt.
5. Diana Mist [2]	February 11	Less than 20 kt.
6. Cumarin	February 25	20 to 200 kt.
7. Yannigan	February 26	20 to 200 kt.
8. Cyathus	March 6	Less than 20 kt.
9. Arabis	do	Less than 20 kt.
10. Jal	March 19	Less than 20 kt.
11. Shaper	March 23	20 to 200 kt.
12. Handley [3]	March 26	More than a megaton.
13. Snubber	April 21	Less than 20 kt.
14. Can	do	20 to 200 kt.
15. Beebalm	May 1	Less than 20 kt.
16. Hod	do	Less than 20 kt.
17. Mint Leaf [2]	May 5	Less than 20 kt.
18. Diamond Dust [2]	May 12	Less than 20 kt.
19. Cornice	May 15	20 to 200 kt.
20. Manzanas	May 21	Less than 20 kt.
21. Morrones	do	20 to 200 kt.
22. Hudson Moon [2]	May 26	Less than 20 kt.
23. Arnica	June 26	20 to 200 kt.
EMERY Series (July–December):		
24. Tijeras	October 14	20 to 200 kt.
25. Abeytas	November 5	20 to 200 kt.
26. Artesia	December 16	20 to 200 kt.
27. Cream	December 16	Less than 20 kt.
28. Carpetbag	December 17	200 kt. to 1 megaton
29. Baneberry	December 18	Less than 20 kt.

[1] Plowshare (peaceful uses) program detonations are not included (see Ch. 9).
[2] DOD test conducted with AEC laboratory assistance.
[3] Conducted in the Pahute Mesa area of the Nevada Test Site.

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	do	Jan. 24, 1970	Jan. 23, 2000
Brazil	Research	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
Colombia	do	Mar. 29, 1963	Mar. 28, 1977
Denmark	do	July 25, 1955	July 24, 1973
Finland	Research and Power	July 7, 1970	July 6, 2000
Greece	Research	Aug. 4, 1955	Aug. 3, 1974
India	Power	Oct. 25, 1963	Oct. 24, 1993
Indonesia	Research	Sept. 21, 1960	Sept. 20, 1980
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, 1980
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.	Feb. 10, 1970	Dec. 31, 1971
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	Jan. 24, 1970
U.S./IAEA/Brazil	do	Oct. 31, 1968
U.S./IAEA/Republic of China	do	Oct. 29, 1965
U.S./IAEA/Columbia	do	Dec. 9, 1970
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	July 19, 1969
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	Do.
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

EDUCATIONAL ACTIVITIES

STATE ORGANIZATIONS COOPERATING IN "THIS ATOMIC WORLD" HIGH SCHOOL LECTURE-DEMONSTRATION PROGRAM

State	Participating organization	First year in program
Alabama	University of Alabama in Birmingham	1969
Arkansas	University of Arkansas	1969
California-Northern	Lawrence Hall of Science	1970
Florida	University of South Florida	1968
Illinois	Northern Illinois University	1969
Kentucky	Morehead State University	1968
Louisiana	Louisiana Board of Nuclear Energy and Louisiana State U.	1968
Michigan—State	Michigan State University	1970
Michigan—Detroit area	do	1970
Nevada	Desert Research Institute of University of Nevada	1970
New York—New York City area	Empire State Atomic Development Associates	1967
New York—Upstate	do	1967
North Carolina	North Carolina State University at Raleigh	1967
Oregon	University of Oregon	1968
Pennsylvania	The Pennsylvania State University	1970
Pennsylvania and Ohio	Geneva College	1969
Texas	Texas A. & M. University	1966
Wisconsin	University of Wisconsin	1968

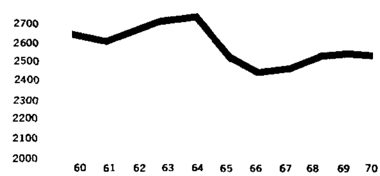
APPENDIX 8

AEC FINANCIAL SUMMARY FOR FISCAL YEAR 1970*

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 greater emphasis on developing and promoting peaceful uses of atomic energy.

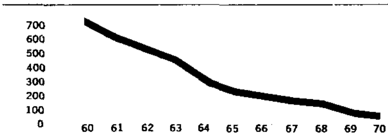
The AEC's operating expenses are approximately $2.5 billion per year. Most of the work involved in achieving AEC goals is performed in Government-owned facilities under contracts with industrial or educational or other nonprofit organizations. These AEC contractors have approximately 106,000 employees engaged in operations and 9,000 in construction work. The AEC has 7,548 employees including 515 temporary and part-time workers.

SUMMARY OF NET OPERATING COSTS

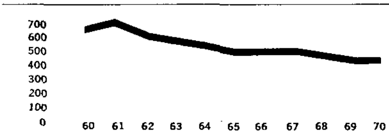


1970 [Millions]

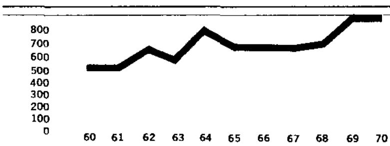
TOTAL OPERATING COSTS $2504 100%



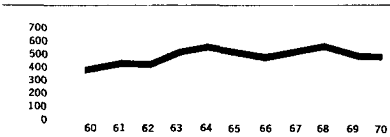
RAW MATERIALS $51 2%



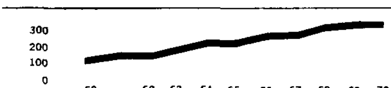
PRODUCTION OF NUCLEAR MATERIALS $490 20%



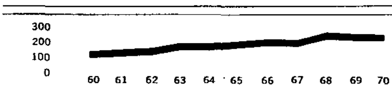
WEAPONS DEVELOPMENT AND FABRICATION $896 36%



REACTOR DEVELOPMENT . . . $496 20%



PHYSICAL RESEARCH $336 13%



OTHER PROGRAMS $235 9%

*Material in this Appendix is extracted from the "U.S. Atomic Energy Commission—1970 Financial Report," available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, price 60 cents.

BALANCE SHEET

Assets*	1970 June 30 (*in thousands*)	1969 June 30 (*in thousands*)
Cash:		
Funds in U.S. Treasury	$1,432,554	$1,665,208
Cash on hand and with contractors	7,186	12,391
Transfers from other agencies	957	1,116
	1,440,697	1,678,715
Accounts Receivable:		
Federal agencies	81,585	36,346
Other	41,250	39,647
	122,835	75,993
Inventories:		
Source and nuclear materials leased and at research installations	1,160,521	1,226,395
Special reactor materials	89,198	106,694
Stores	92,836	87,089
Isotopes	39,091	37,160
Other special materials	13,349	13,997
	1,394,995	1,471,335

Liabilities and AEC Equity*	1970 June 30 (*in thousands*)	1969 June 30 (*in thousands*)
Liabilities:		
Accounts payable and accrued expenses	$330,192	$323,140
Advances from other agencies	957	1,116
Funds held for others	9,823	9,747
Accrued annual leave of AEC employees	12,999	11,302
Deferred credits	118,716	84,254
Total liabilities	472,687	429,559
AEC equity, July 1	8,419,252	8,190,173
Additions:		
Funds appropriated—net	2,222,316	2,615,844
Non-reimbursable transfers from other agencies	3,231	4,783
	2,225,547	2,620,627

Plant:		
Completed plant and equipment	9,173,055	9,012,196
Less—Accumulated depreciation	4,188,304	3,905,230
	4,984,751	5,106,966
Construction work in progress	555,105	441,685
	5,539,856	5,548,651
Other	79,614	74,117
Total assets	$8,577,997	$8,848,811

Deductions:		
Net cost of operations—after special items	2,521,117	2,377,103
Non-reimbursable transfers to other agencies	16,651	14,445
Funds returned to U.S. Treasury	1,721	
	2,539,489	2,391,548
AEC equity, June 30	8,105,310	8,419,252
Total liabilities and AEC equity	$8,577,997	$8,848,811

* 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. Plant and equipment on loan from other Federal agencies at June 30, 1970, amounting to $10,739,000.
   c. Contested claims against others of $1,038,000.
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, 1970, the estimated liabilities would have amounted to $450,530,000.
   b. Contingent liabilities for claims against the AEC of $48,894,000.
   c. Commitments for an estimated 1,390 tons of U_3O_8 at an estimated cost of $16,015,000. All contractss for procurement of U_3O_8 will expire Dec. 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 Dec. 31, 1970.
   e. Outstanding contracts, purchase orders and other commitments of $1,268,500,000.

STATEMENT OF OPERATIONS

	Fiscal year	
	1970	1969
	(in thousands)	
Production:		
Raw materials	$50, 652	$101, 032
Production of nuclear materials	489, 820	495, 244
Weapons development and fabrication	896, 035	897, 802
	1, 436, 507	1, 494, 078
Research and Development:		
Development of nuclear reactors	496, 297	508, 442
Physical research	335, 883	331, 638
Biology and medicine research	99, 957	99, 105
Plowshare	16, 251	14, 963
Isotope development	7, 400	7, 629
	955, 788	961, 777
Community Operations:		
Expenses	423	725
Revenues	(31)	(381)
	392	344
Sales of Materials and Services:		
Cost	143, 715	92, 207)
Revenue	(168, 042)	(103, 989
	(24, 327)	(11, 782)
Education and training	9, 484	10, 259
AEC administrative expenses	124, 065	108, 204
Security investigations	7, 180	7, 178
Other expenses	16, 466	13, 377
Other income	(21, 863)	(17, 186)
Net cost of operations*	2, 503, 692	2, 566, 249
Special Items:		
Adjustments to costs of prior years—net	46, 482	11, 761
Transfers to inventories—net	(29, 057)	(200, 907)
Net cost of operation—after special items*	$2, 521, 117	$2, 377, 103

* Includes depreciation of $390 million in 1970 and $381 million in 1969.

RESEARCH LABORATORIES

A major portion of AEC research and development is conducted in Government-owned laboratories operated by educational institutions, industrial concerns and nonprofit organizations under AEC contracts. On June 30, 1970, the AEC's investment in research facilities totaled $3.2 billion. Of this amount, $2.3 billion was invested in the major Government-owned laboratories. These facilities include research reactors, accelerators, general laboratory buildings, equipment and research devices.

The basic research carried out in the AEC laboratories, while generally 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. As in the past, the basic knowledge arising from AEC programs will continue to make contributions to non-AEC programs of great national significance.

A portion of AEC laboratory capabilities is being used on problems of other agencies, giving due regard to the AEC mission and the interface it has with the interests of other agencies.

Laboratories	Cost of completed plant June 30, 1970	Operating costs, fiscal year	
		1970	1969
	(in thousands)		
Ames Research Laboratory	$25,314	$8,935	$9,023
Argonne National Laboratory [1]	385,360	105,483	120,990
Bettis Atomic Power Laboratory [1]	141,829	85,716	75,428
Brookhaven National Laboratory	248,048	67,654	62,163
Knolls Atomic Power Laboratory [1]	151,106	69,326	64,666
Lawrence Radiation Laboratory [2]	367,532	183,752	177,975
Los Alamos Scientific Laboratory [2]	282,229	121,116	109,301
Oak Ridge National Laboratory	363,696	100,115	90,347
Pacific Northwest Laboratory	110,121	61,987	56,194
Savannah River Laboratory	79,977	13,554	13,913
Stanford Linear Accelerator	146,722	31,409	30,556

[1] Includes facilities at NRTS, Idaho.
[2] Includes facilities in Nevada.

412-406--71——22

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 1970, the AEC's prime industrial contractors accomplished work amounting to $1,647 million. The table on this page 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 1970: Rank by dollar volume of costs incurred	Fiscal year 1970: Total costs* (*in thousands*)
Aerojet-General Corp	18	$26,344
Anaconda Co	25	6,784
Atlantic Richfield Hanford Co	13	36,618
Atomic Int'l Div., North American Rockwell Corp	17	26,404
Bendix Corp	4	92,209
Douglas United Nuclear, Inc	10	42,938
Dow Chemical Co	8	58,221
EG&G, Inc	11	38,690
E. I. du Pont de Nemours & Co	3	116,553
General Electric Co	6	87,377
Goodyear Atomic Corp	14	35,133
Gulf General Atomic, Inc	23	8,248
Holmes & Narver, Inc	12	37,679
Idaho Nuclear Corp	9	48,081
Kerr-McGee Corp	22	9,118
Mason & Hanger-Silas Mason Co	16	30,082
Monsanto Research Corp	15	33,211
National Lead Co	21	17,492
Pan American World Airways, Inc	27	5,365
Reynolds Electrical & Engineering Co., Inc	5	91,584
Rust Engineering Co	20	20,661
Sandia Corp	2	220,283
Swinerton & Walberg Co	19	25,216
TRW, Inc	28	5,001
Union Carbide Corp	1	319,124
United Nuclear Corp	26	6,707
United Nuclear Homestake Partners	24	7,536
Westinghouse Electric Corp	7	83,529
Other (321 industrial organizations)		111,296
Total		$1,647,484

*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	$37.7	$2.9	$11.9	$52.5
California Institute of Technology, Pasadena Research Facilities	1.8	2.0		3.8
University of California, Lawrence Radiation Laboratory:				
Berkeley	126.7	3.6	18.2	148.5
Livermore	229.8	8.4	17.6	255.8
Total Lawrence Radiation Laboratory	356.5	12.0	35.8	404.3
University of California, Davis Bio-Med Research Facilities	5.4	.2	.4	6.0
University of California, Los Angeles Medical Research Facilities	2.8	.2	.6	3.6
EG&G, Inc., Santa Barbara Test Facilities	2.0	.1		2.1
EG&G, Inc., San Ramon Test Facilities	1.6	.2	2.7	4.5
Gulf General Atomic Inc., San Diego Research Equipment	2.2	.1	.4	2.7
Sandia Corp., Livermore Research Facilities	37.7	.7	8.1	46.5
Stanford University, Palo Alto Linear Accelerator & Equipment	146.7	2.9	8.3	157.9
Total California	594.4	21.3	68.2	683.9
COLORADO				
University of Colorado, Boulder	1.8		.1	1.9
Dow Chemical Co., Rocky Flats	131.0	85.2	52.5	268.7
Lucius Pitkin, Inc., Grand Junction Uranium handling, Sampling and General Facilities	5.0		.3	5.3
Total Colorado	137.8	85.2	52.9	275.9
CONNECTICUT				
Combustion Engineering, Inc., Windsor Submarine Reactor Facilities	15.1			15.1
Yale University, New Haven Linear Accelerator	10.5		.5	11.0
Total Connecticut	25.6		.5	26.1
FLORIDA				
General Electric Co., Clearwater Pinellas Plant	25.9	4.2	2.7	32.8

See footnote 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
IDAHO				
National Reactor Testing Station, Idaho Falls				
Argonne National Laboratory				
Reactor Facilities	$48.5	$3.2	$16.6	$68.3
General Electric Co.				
Knolls Atomic Power Laboratory	25.8	.1	.2	26.1
Idaho Nuclear Corp.				
Advanced Test Reactor	50.5	6.7	.7	57.9
Auxiliary Reactor Area	6.4	.1	.1	6.6
Chemical Processing Plant	65.9	.9	3.8	70.6
Engineering Test Reactor	14.8		.1	14.9
General Facilities	63.6	.3	5.6	69.5
Materials Test Reactor	11.4		.1	11.5
Nuclear Safety Testing Engineering	5.8	25.9	9.6	41.3
Power Burst Facility	.4	14.0	2.4	16.8
Special Power Excursion Reactor Test	9.5	.1	.2	9.8
Test Reactor Area	21.4	.3	.2	21.9
Total Idaho Nuclear Corp	249.7	48.3	22.8	320.8
Westinghouse Electric Corp.				
Large Ship Reactor	35.8			35.8
Submarine Thermal Reactor	17.3			17.3
Other Research Facilities	19.5	2.5	8.7	30.7
Total Westinghouse Electric Corp	72.6	2.5	8.7	83.8
Total Idaho	396.6	54.1	48.3	499.0
ILLINOIS				
University of Chicago, Argonne				
Argonne National Laboratory	336.9	28.0	23.7	388.6
University of Chicago, Chicago				
Argonne Cancer Research Hospital	7.1	.5	.4	8.0
University of Illinois, Urbana				
Research Facilities	.8		.5	1.3
Universities Research Assoc., Batavia				
National Accelerator Laboratory		57.7	192.3	250.0
Land and Other Research Facilities	24.0	.3	9.9	34.2
Total National Accelerator Laboratory	24.0	58.0	202.2	284.2
Total Illinois	368.8	86.5	226.8	682.1
INDIANA				
University of Notre Dame, Notre Dame				
Radiation Laboratory	3.3		.2	3.5
IOWA				
Ames Research Laboratory, Ames				
Research Facilities	20.6	.8	1.8	23.2
Research Reactor	4.7			4.7
Mason and Hanger, Burlington	43.1	6.5	5.6	55.2
Total Iowa	68.4	7.3	7.4	83.1

See footnote 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 Material Facility	$26.7			$26.7
Gaseous Diffusion Plant	761.4	$1.9	$5.5	768.8
Total Kentucky	788.1	1.9	5.5	795.5
MARYLAND				
AEC Headquarters, Germantown	23.9	.2	4.2	28.3
University of Maryland, College Park				
Accelerator	1.0	3.5	.2	4.7
Total Maryland	24.9	3.7	4.4	33.0
MASSACHUSETTS				
EG&G, Inc., Boston				
Test Facilities	3.3	1.2	1.5	6.0
Harvard University, Cambridge				
Cambridge Accelerator	24.7	1.3	1.0	27.0
Massachusetts Institute of Technology, Cambridge				
Research Facilities	9.7	4.9	2.0	16.6
Total Massachusetts	37.7	7.4	4.5	49.6
MICHIGAN				
University of Michigan, Ann Arbor				
Research Facilities	2.7		.1	2.8
Michigan State University, East Lansing				
Research Facilities	1.7		.2	1.9
Total Michigan	4.4		.3	4.7
MINNESOTA				
University of Minnesota, Minneapolis				
Accelerator	4.2	.2	.1	4.5
Rural Cooperative Power Asso., Elk River				
Elk River Reactor	10.7			10.7
Total Minnesota	14.9	.2	.1	15.2
MISSOURI				
The Bendix Corp., Kansas City	79.8	16.1	29.2	125.1
NEVADA				
Jackass Flats:				
Nuclear Rocket Development Station—Project Rover:				
University of California, Los Alamos Scientific Laboratory	4.3			4.3
Pan American World Airways, Inc	79.0	1.7	3.4	84.1
Westinghouse Electric Corp	2.6			2.6
Other Research Facilities	3.2			3.2
Total Jackass Flats	89.1	1.7	3.4	94.2

See footnote 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
Mercury:				
EG&G, Inc.				
Test Facilities	$25.0	$0.4	$2.6	$28.0
Lawrence Radiation Laboratory				
Laboratory Facilities	11.0			11.0
Reynolds Electrical & Engineering Co.				
Nevada Test Site	139.9	2.0	19.5	161.4
Total Mercury	175.9	2.4	22.1	200.4
Sandia Corp., Tonopah				
Research Facilities	14.5	.4	3.2	18.1
Total Nevada	279.5	4.5	28.7	312.7
NEW JERSEY				
Atomic Energy Commission, New Brunswick				
New Brunswick Laboratory	2.9	1.4	.4	4.7
Princeton University, Princeton				
Model C Stellarator Facilities	25.8	.2	.8	26.8
Princeton-Pennsylvania Accelerator	37.9	2.7	.8	41.4
Total New Jersey	66.6	4.3	2.0	72.9
NEW MEXICO				
Albuquerque:				
EG&G, Inc.				
Test Facilities	4.5		.5	5.0
Lovelace Foundation Laboratory	5.1	.2	.8	6.1
Sandia Corp.				
Sandia Laboratory	222.5	4.7	26.7	253.9
Total Albuquerque	232.1	4.9	28.0	265.0
Los Alamos:				
University of California				
Los Alamos Scientific Laboratory	277.9	33.3	65.9	377.1
The Zia Co.				
General Maintenance Facilities	57.9	.1	.6	58.6
Total Los Alamos	335.8	33.4	66.5	435.7
Total New Mexico	567.9	38.3	94.5	700.7
NEW YORK				
New York City:				
Atomic Energy Commission				
Health and Safety Laboratory	2.7		.3	3.0
Columbia University				
Accelerator and Research Facilities	5.3		.4	5.7
New York University				
Computing and Other Research Facilities	4.3		.1	4.4
Total New York City	12.3		.8	13.1
Associated Universities, Inc., Upton				
Brookhaven National Laboratory	248.0	48.2	18.5	314.7

See footnote 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
General Electric Co., Schenectady and West Milton				
Knolls Atomic Power Laboratory	$125.3	$8.2	$25.9	$159.4
Nuclear Materials and Equipment Corp., Niagara Falls				
Boron Plant	7.3			7.3
Rensselaer Polytechnic Inst., Troy				
Accelerator Facility	3.1		.1	3.2
University of Rochester, Rochester				
Medical Laboratory and 130" Cyclotron	7.1		.5	7.6
Total New York	403.1	56.4	45.8	505.3
NORTH CAROLINA				
Duke University, Durham				
Accelerator and Research Facilities	1.1	2.5	.1	3.7
OHIO				
Battelle Memorial Inst., Columbus				
Research Facilities	.9			.9
Goodyear Atomic Corp., Portsmouth				
Feed Material Facility	7.2			7.2
Gaseous Diffusion Plant	760.9	1.4	6.1	768.4
Monsanto Chemical Co., Miamisburg				
Mound Laboratory	67.7	15.6	14.3	97.6
National Lead Co., Fernald				
Feed Material Facility	118.9	.3	.9	120.1
Ohio University, Athens				
Research Facilities		.5	.5	1.0
Reactive Metals, Inc., Ashtabula				
Feed Material Facility	1.8		.2	2.0
Total Ohio	957.4	17.8	22.0	997.2
PENNSYLVANIA				
Carnegie-Mellon University, Pittsburgh				
Accelerator and Research Facilities	1.1			1.1
Duquesne Light Co., Shippingport				
Shippingport Atomic Power Station	63.4	.5	2.8	66.7
Westinghouse Electric Corp., Large				
Astronuclear Laboratory	10.6	.9	5.5	17.0
Westinghouse Electric Corp, Pittsburgh				
Bettis Atomic Power Laboratory	69.2	8.0	23.1	100.3
Total Pennsylvania	144.3	9.4	31.4	185.1
SOUTH CAROLINA				
E. I. Du Pont de Nemours and Co., Inc., Aiken				
Savannah River Plant				
Feed Material Facility	33.0	1.1		34.1
General Facilities	147.2	3.8	3.4	154.4
Heavy Water Production Facilities	162.9			162.9
Laboratory	80.0	2.5	3.4	85.9
Production Reactor and Separation Facilities	898.6	3.8	22.1	924.5
Total South Carolina	1,321.7	11.2	28.9	1,361.8

See footnote 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	$6.6		$0.4	$7.0
Rust Engineering Co.				
Service Facilities	10.2		.1	10.3
University of Tennessee				
Agriculture Research Laboratory and Farm	3.8	$0.1	.2	4.1
Union Carbide Corp.				
Feed Material Facility	2.7			2.7
Gaseous Diffusion Plant	831.8	3.0	29.3	864.1
Oak Ridge National Laboratory	363.7	7.7	18.9	390.3
Y-12 Plant	439.8	80.2	55.6	575.6
Total Tennessee	1,658.6	91.0	104.5	1,854.1
TEXAS				
Mason and Hanger, Amarillo				
Pantex Plant	61.9	6.1	9.8	77.8
Rice University, Houston				
Research Facility	1.9		.1	2.0
Texas A&M University, College Station				
Research Facilities		3.1	.3	3.4
Total Texas	63.8	9.2	10.2	83.2
UTAH				
University of Utah, Salt Lake City	1.4		.3	1.7
WASHINGTON				
Richland:				
Atlantic Richfield Hanford Co.				
Separation and Production Facilities	242.3	5.8	33.9	282.0
Battelle Memorial Inst.				
Pacific Northwest Laboratory	110.1	11.5	105.0	226.6
Computer Sciences Corp.				
General Facilities	4.0	.1		4.1
Douglas United Nuclear, Inc.				
Feed Material Facility	26.0	.1		26.1
General Facilities	14.9			14.9
Production Reactor Facilities	580.0	2.6	5.9	588.5
Total Douglas United Nuclear, Inc.	620.9	2.7	5.9	629.5
ITT/Federal Support Services, Inc.				
General Facilities	64.9	.4	1.4	66.7
J. A. Jones Construction Co.				
General Facilities	2.7			2.7
WADCO (Westinghouse Electric Corp. subsidiary)			2.6	2.6
Total Washington	1,044.9	20.5	148.8	1,214.2
WEST VIRGINIA				
International Nickel Co., Huntington				
Pilot Plant	4.7			4.7

See footnote 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
WISCONSIN				
Dairyland Power Coop., Genoa				
LaCrosse Boiling Water Reactor	$10.5		$0.6	$11.1
University of Wisconsin, Madison				
Research Facilities	2.0		.2	2.2
Total Wisconsin	12.5		.8	13.3
PUERTO RICO				
University of Puerto Rico, Mayaguez and Rio Piedras				
Puerto Rico Nuclear Center	7.5	$1.4	1.4	10.3
JAPAN				
National Academy of Sciences, Hiroshima				
Research Facilities	3.1	.1	.2	3.4
All other	64.4	.6	45.6	110.6
Total	9,173.1	555.1	1,016.2	10,744.4

[1] Includes plant and capital equipment authorized in Public Law 91-273, approved June 2, 1970.

INDEX

D

E

F