UNITED STATES ATOMIC ENERGY COMMISSION

Annual Report to Congress

OF THE

ATOMIC ENERGY COMMISSION

FOR

1968

January 1969

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

LETTER OF SUBMITTAL

WASHINGTON, D.C.,
January 31, 1969.

SIRS: We have the honor to submit herewith the Annual Report of the United States Atomic Energy Commission for 1968 as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
JAMES T. RAMEY.
GERALD F. TAPE.
WILFRID E. JOHNSON.
FRANCESCO COSTAGLIOLA.
GLENN T. SEABORG, *Chairman.*

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

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The AEC's 1968 Enrico Fermi Award was presented by President Lyndon B. Johnson to Dr. John Archibald Wheeler (*center*) in a White House ceremony on December 2. Dr. Glenn T. Seaborg, Chairman of the Atomic Energy Commission participated in the ceremony. Dr. Wheeler, the Joseph Henry Professor of Physics at Princeton University, Princeton, N.J., was selected for the 1968 Fermi Award for "his pioneering contributions to understanding nuclear fission, and to developing the technology of plutonium production reactors, and his continuing broad contributions to nuclear science." The award consists of a gold medal, a citation, and $25,000. The award is named for the late Dr. Enrico Fermi, leader of the group of scientists who achieved the first sustained controlled nuclear chain reaction on December 2, 1942, at Stagg Field, Chicago. The award to Dr. Wheeler was made on the 26th anniversary of Dr. Fermi's achievement.

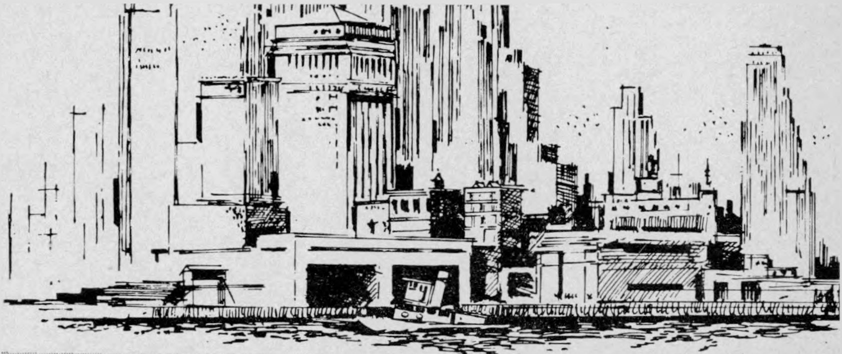
An Introduction To:

The Atomic Energy Program During 1968

The year 1968 was marked by heavier industrial commitment to a long-term and broadened nuclear endeavor, not just power reactors alone. It was also a year in which the delayed effects of activities of earlier years toward enhancement of a stronger role for industry in the Nation's atomic energy program became more evident.

As had been expected, the unprecedented surge in power reactor orders that had started in 1965 finally tapered off—at least a year later than most had anticipated. It left a strong and viable nuclear industry that had developed earlier and grown more rapidly than had been thought possible. The 1964 private ownership legislation covering special nuclear materials—permissive now, mandatory in 1973—has paved the way for greater industrial participation in the nuclear power and associated business activities. From the exploration for new uranium reserves to the production of reactor fuel elements, from the fabrication of reactors and their components to the reprocessing of "spent" fuel elements, the industry committed itself to greater and greater involvement during the year. Among the indications of continuing economic growth and vigor of the Nation's young nuclear services industry were: new capital expenditures, new ideas, for research and development, and new personnel training to meet the needs of the future. From a government monopoly (1942–1964), the nuclear economic climate has changed to one where virtually all activities are in the commercial-industrial sphere of the Nation's economy. Now, the Federal Government's last vestige of monopoly—the uranium enrichment process—is under study for means of moving it over into the private sector.

There are several reasons why nuclear powerplant orders have reached a plateau. Utility orders for new electric generating equipment typically follow a cyclical pattern. The leadtime between ordering a nuclear reactor plant and putting it into operation can be up to $2\frac{1}{2}$ years longer than for fossil-fueled plants; thus, foresighted electric utility managements acted to get their orders in before the manufacturing capacity was saturated. Important also is the fact that the



A Single Truckload of enriched uranium-235 (like the *above* shipment from the Oak Ridge Gaseous Diffusion Plant) can supply the total electrical power needs for a city of 200,000 people—such as Mobile, Ala., Providence, R.I., or Tacoma, Wash.—for an entire year. The generation of electricity continues to be the most dramatic peaceful application of nuclear energy in the United States. At the end of 1968, there were 57 nuclear powerplants either in operation or under construction in the U.S., and some 42 more were planned. During 1968, the AEC authorized construction of 23 nuclear plants which, when completed, will represent an initial investment of about $3 billion by the Nation's electric utilities. While only five new plants are expected to begin operation in 1969, some 67 are scheduled to start operation during the 1970–1975 period (see Table 1 on pages 13–15). The AEC estimates that by 1980, the capacity of nuclear generating plants will probably be between 120,000 and 170,000 megawatts—about 25 percent of the Nation's total. (A megawatt is 1,000 kilowatts.)

plants ordered since 1965 are larger than any in operation today; and, since none of these larger plants are yet in operation, their designed efficiency is yet to be proven. Like any new industrial endeavor there are large and small problems that must be solved before construction and operation reach the point of economic efficiency. For instance, the resolution of today's problems with heavy steel—cracks and welding flaws—will make for easier fabrication of tomorrow's reactors.

Although the number of nuclear units proposed for construction by electric utilities tapered off to 13 during 1968, as compared with the 1967 peak of 29 units, the trend to sizable nuclear central station powerplants is well underway. Today's largest operating nuclear plant has a capacity of 462 megawatts of electricity (Mwe.). Three of the 1968 applications were for plants exceeding 1,000 Mwe., and eight were in the 800-Mwe. class. During the year, the AEC issued construction permits for 23 new nuclear power reactors with a total design capacity of over 18,000 Mwe.—seven times the total operating domestic nuclear powerplant capacity of today. Construction of these 23 plants will represent an initial utility investment of over $3 billion. At year's end, there were 44 nuclear power units under construction and nearly all of these are scheduled to be in operation over the next 5 years. No new plants began operations during 1968, but several are scheduled to start up during 1969.

This year, as on several earlier occasions, the facility licensing process was itself under review with an eye toward making the process more amenable to the rapid expansion of the nuclear industry and the continuing technological advances that will mark future generations of power reactors. The study includes consideration of how to improve the decisionmaking and review processes of the AEC's regulatory system.

Commissioners Terms

On March 1, 1968, Dr. Glenn T. Seaborg began his 8th year as Chairman of the Atomic Energy Commission. He has held the chairmanship longer than any other individual in the 22-year history of the AEC. Dr. Seaborg's nomination for a new appointment ending on June 30, 1970, was unanimously confirmed by the U.S. Senate on June 28. On January 28, 1969, President Nixon requested Dr. Seaborg to continue as Chairman.

Commissioner James T. Ramey, who has served as a member of the AEC since August 1962, was unanimously confirmed by the Senate on June 28 for a new 5-year term which will expire June 30, 1973.

327-679—69——2

Californium-252, a Manmade Heavy Element radioisotope may be a useful "tool" for mineral exploration. A pellet of compacted platinum foil of the size used to contain a californium-252 neutron source is shown in the photo at *left*. (The actual source would be too radioactively "hot" to handle.) The actual neutron source is being evaluated for mineral exploration by the U.S. Geological Survey (USGS). Preliminary tests indicate some promise for californium-252 sources in identification of ores containing gold and silver. In another experiment, the USGS used a californium-252 source to determine the moisture content and porosity of rocks in a drill hole (photo *below*) using neutron activation as a type of geophysical well-logging. The source and a detector were lowered into a drill hole to a depth of 1,100 feet. The neutrons irradiate the wall materials and the detector picks up the "profile" of the induced activity which can be identified by its energy. The technique, usable in wells of any depth, may be used in locating water or oil. (See illustrations and text in Chapter 1—"Source, Special, and Byproduct Materials.")

Commissioners Gerald F. Tape and Wilfrid E. Johnson are currently serving 5-year terms of office which expire in 1971 and 1972, respectively. Commissioner Johnson was first sworn in during August 1966; Dr. Tape was sworn in as a member of the Commission in July 1963.

Commissioner Francesco Costagliola, Captain, USN (Ret.), was sworn in as an AEC member on October 1, 1968, to fill a vacancy on the Commission for a term which expires on June 30, 1969. At the time of his appointment to the AEC, Captain Costagliola was serving as a staff consultant to the Congressional Joint Committee on Atomic Energy; he has been closely associated with applications of atomic energy over a number of years.

AEC Programs and the Non-Proliferation Treaty

On July 1, 1968, representatives of the United States, United Kingdom, and Union of Soviet Socialist Republics, and more than 50 other countries signed the Treaty on the Non-Proliferation of Nuclear Weapons. The treaty has since been signed by additional countries bringing the total to more than 80 nations. The U.S. Senate's Committee on Foreign Relations reported favorably on the treaty on September 26 and recommended that the Senate give its advice and consent to ratification of the treaty. However, the Senate adjourned on October 14 without taking action.

Under Article I of the Non-Proliferation Treaty (NPT) nuclear-weapon-states party to the treaty are prohibited from transferring nuclear weapons or nuclear explosive devices, or control over them, to any recipient whatsoever, and from assisting, encouraging, or inducing any nonnuclear-weapon state to acquire them. Article II prohibits the manufacture or acquisition of nuclear weapons or other nuclear explosive devices by nonnuclear-weapon parties. Under Article III, nonnuclear-weapon parties undertake to accept safeguards, "with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices." The safeguards are to be applied to "all source or special fissionable material in all peaceful nuclear activities within the territory of such State * * *."

While the NPT does not impose any obligations on the part of nuclear-weapon parties to permit safeguards on their activities, on December 2, 1967, President Johnson had announced that "* * * when such safeguards are applied under the treaty, the United States will permit the International Atomic Energy Agency (IAEA) to apply its safeguards to all nuclear activities in the United States—excluding only those with direct national security significance. * * *"

The objective of the President's offer was to meet the concerns expressed by some nonnuclear-weapon states that the application of safeguards would present risks of industrial espionage, interference with operations, and other possible economic burdens, leading to an unfavorable international competitive position for their peaceful nuclear industries.

Some nonnuclear-weapon states also expressed the view that a nonproliferation treaty would prejudice their opportunity to share in the peaceful applications of nuclear energy. Therefore, Article IV contains positive provisions concerning cooperation in the field of peaceful

Five Young Nuclear Scientists received the AEC's 1968 E. O. Lawrence Memorial Award on May 20, during the dedication of the Lawrence Hall of Science at the University of California, Berkeley. Each of the scientists received $5,000, a citation, and a gold medal. The AEC makes the award on the basis of recommendations from its General Advisory Committee and with the approval of the President. Those who received the award in 1968 and their citations were, left to right: *Dr. James R. Arnold*, Professor of Chemistry, University of California at San Diego—"for his leadership and many imaginative contributions in the development and applications of nuclear techniques in research." *Dr. E. Richard Cohen*, Associate Director, the Science Center North American Rockwell Corp., Thousand Oaks, Calif.—"for his many highly original contributions to neutron transport theory and reactor physics and for his evaluation of the fundamental constants of physics and chemistry." *Dr. Val L. Fitch*, Professor of Physics, Princeton University, Princeton, N.J.—"for his brilliant research on mesons which has added to our knowledge of both mesons and nuclear structure and has shown the fundamental asymmetry of nature * * *." *Dr. Richard Latter*, RAND Research Council, The RAND Corp., Santa Monica, Calif.—"for his many and varied contributions to the theory of nuclear weapon design and weapons effects and for his outstanding dedication and considered judgment in matters of defense policy and strategy." *Dr. John B. Storer*, Deputy Director, Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C.—"for his many valuable contributions to the understanding of the relative biological effect of ionizing radiations and for his fundamental studies of * * * radiation injury."

uses of nuclear energy. Additionally, Article V contains a commitment for parties to take appropriate measures to insure that the potential benefits of peaceful applications of nuclear explosions will be made available to nonnuclear-weapon parties, on a nondiscriminatory basis, through the provision by nuclear-weapon states of peaceful nuclear explosion services. The charges for the devices used will be as low as possible and will exclude any charge for research and development on the devices. Requests by nonnuclear-weapon parties for the explosion services are to be made either through an international body (which the United States believes should be the IAEA) or directly to a nuclear-weapon state. In either case, an opportunity is to be provided for appropriate international observation.

Articles IV and V reflect, in large part, confidence that the treaty will inspire a kind of international cooperation in the peaceful uses of nuclear energy that will not contribute to the acquisition of nuclear weapons. As President Johnson stated, the United States will engage in "* * * the fullest possible exchange of equipment, materials, and scientific and technological information for the peaceful uses of atomic energy * * *" pursuant to the provisions of the treaty. Thus, the Non-Proliferation Treaty will facilitate the continuation and expansion of AEC's programs relating to international cooperation in the peaceful applications of nuclear energy, and will have an important impact on other international activities, particularly those of the IAEA.

CONTENTS SUMMARY

The next 17 pages of this "Annual Report to Congress for 1968" [1] briefly summarize the contents on a chapter-by-chapter basis. Results of AEC-sponsored basic research and development are included in the supplemental report, "Fundamental Nuclear Energy Research—1968." [2]

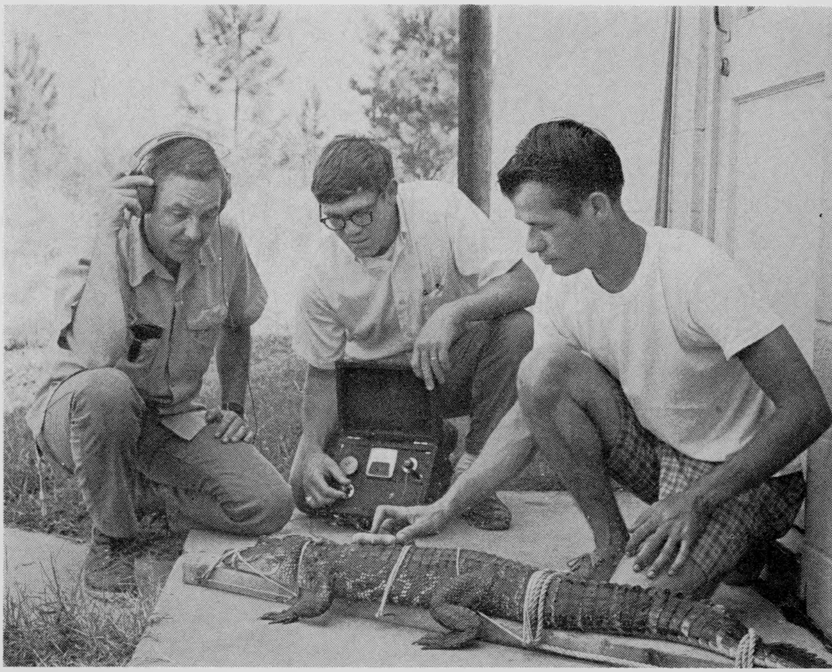
Source and Special Nuclear Materials

● During 1968, a record amount of uranium ore exploration was accomplished. As a result of exploration efforts over recent years, known ore reserves were increased by the largest amount during any year since 1959.

[1] This "Annual Report to Congress for 1968" is available to the public under an alternate title, "Major Activities in the Atomic Energy Programs—January–December 1968," from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.75.

[2] "Fundamental Nuclear Energy Research—1968" is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $4.25.

● AEC uranium procurement at the fixed price of $8 per pound of uranium oxide in ore concentrate was completed during 1968. Prices for 1969 and 1970, the final 2 years of the Government procurement program, will be based on contractor costs of production for 1963 through 1968 and are currently expected to average just under $6 per pound.



Plagued by Hide-Poachers, wetland drainage, destruction of habitat, and water pollution, the American alligator has long been on the Nation's "endangered wildlife species" list. In what may be a last stand in the battle for survival, alligators have found a haven from the perils of civilization on the AEC's 315 square mile Savannah River production and research facility reservation. Heat from the water coolant used in the nuclear reactors helps to keep water temperatures favorable all year round. The area has been closed to the general public since 1952, allowing the wildlife of the area freedom from hunting. Photo shows a sonar transmitter being sutured to an alligator's armored back before release. Its underwater signals, detected by hydrophone, permit relocating and following the 'gator as a part of studies to devise management programs aimed at insuring long-term survival of the alligator throughout the entire southeastern U.S. The Aiken, S.C., plant is near the northern limit of the alligator's natural range. The study of the alligators is only one of a number of long-range research programs being made by the Savannah River Ecology Laboratory aimed toward a better understanding of how natural populations and systems operate free from the influence of man and civilization. The ecology laboratory is operated by tne University of Georgia, under an AEC contract.

● AEC uranium sales policy was clarified. In general, future sales prior to June 30, 1973, are conditioned on the unavailability of uranium from domestic commercial sources at reasonable prices or on reasonable time schedules.

● Additional commercial sales of uranium by the industry were made during the year; but further substantial amounts must be committed to meet requirements projected for the midseventies and beyond.

● A report of an industry association study committee on uranium enrichment facilities concluded that it is desirable and feasible for AEC to transfer Government-owned enrichment plants promptly to the industrial sector of the economy. An AEC internal study on the subject is continuing. The topic is expected to come up in public hearings before the Congressional Joint Committee on Atomic Energy.

● While the closing down of five production reactors since 1964 at the Hanford Works in Washington was undertaken as an economy measure after consideration of the supply-demand outlook, the shutdowns have also reduced the heat and radioactivity levels discharged to the Columbia River. A 1968 U.S. Geological Survey report covering the 1964–66 period (during which three reactors were shut down) shows a significant decrease in the levels of radioactivity in the river—the levels have always been well below the levels established as permissible for safety.

● During the year, steps were taken to increase the production of the manmade heavy element californium-252 at the Savannah River Plant, and the first phase of a market-development program for the intense neutron-emitting radioisotope was undertaken.

● The AEC withdrew from the sale of cobalt-60 sources of 45 curies per gram or less specific activity; thus withdrawing from all routine cobalt-60 sales.[3] Since 1961, the AEC has withdrawn from production and sale of 37 radioisotopes as commercial suppliers demonstrated a capability to handle the market on a competitive basis.

Safeguards and Materials Management

● To preclude diversion of special nuclear materials to unauthorized use, reporting requirements were extended to all privately owned special nuclear materials, regardless of origin, except for small quantities.

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[3] Exceptions will be made where material is not reasonably available from commercial sources.

● The AEC assisted the International Atomic Energy Agency (IAEA) in preparing for the agency's safeguards role under the terms of the Non-Proliferation Treaty by sharing technology and by training safeguards inspection personnel.

The Nuclear Defense Effort

● Nuclear weapons testing continued underground at the Nevada Test Site (NTS). The AEC and the Department of Defense announced 29 tests during the year; of these, 23 were development tests; 5 were nuclear effects tests; and 1 was to improve detection systems.

● A request was made to provide $315 million for construction of additional production facilities for new weapons systems required by the Defense Department. Included in the $315 million was $285 million previously authorized.

● Three larger-yield nuclear weapons tests were conducted in 1968. One was conducted at the Central Nevada test area and two on Pahute Mesa at the NTS. These tests, in addition to providing programmatic information, produced data on seismic effects and on the possible use of the areas for future tests.

Naval Propulsion Reactors

● The guided-missile frigate *Truxtun* completed her first Vietnam combat deployment; the guided-missile cruiser *Long Beach* her second; and the aircraft carrier *Enterprise* her third. The operation of these nuclear-powered surface ships continues to demonstrate, under actual combat conditions, the significant advantages of nuclear propulsion for surface warships.

● The keel of the *Nimitz*, the Navy's second nuclear-powered aircraft carrier, was laid on June 22, 1968.

● The President approved a recommendation by the Secretary of Defense to complete two all-nuclear attack carrier task groups.

● The AEC received approval to accelerate work on development of the reactor plant for a nuclear-powered submarine capable of higher operating speed than present attack submarines.

Reactor Development and Technology

● Electric utilities continued the trend toward nuclear power that began in 1965 as a reevaluation of the reactor development program was made with industrial participation to assist future development efforts.

● Emphasis on fast breeder reactor development was continued; primarily, on the Liquid Metal-Cooled Fast Breeder Reactor. Efforts also were continued on other breeder concepts—the molten salt, gas cooled, and light water breeder reactors.

● The AEC continued work on other reactor concepts, such as converters and advanced converters to improve their operating efficiency and safety.

● Initiation of the Bolsa Island nuclear power and desalting project was deferred pending an evaluation of other alternatives which could enhance the economics of the project; a decision by the Metropolitan Water District to defer the project for several years is currently being reviewed by the Government.

Licensing and Regulating the Atom

● The AEC authorized construction of 23 nuclear power reactors in 1968. These units represent an initial utility capital investment of more than $3 billion and a total design capacity exceeding 18,000 Mwe. This brought to 44 the number of nuclear power units under construction, nearly all of which are scheduled to begin commercial operation during the next 5 years.

● The volume of construction permit applications tapered off from the peak of 1967 (13 received in 1968 *vs.* 29 in 1967). Emphasis increased on quality in design and construction of the large number of plants underway. AEC inspections were increased. Progress was made in developing and improving reactor safety standards and codes.

● A new study group launched a technically oriented study of the timing of steps in the licensing of nuclear facilities and of the coordination in the decisionmaking and regulatory review processes.

● Increasing public attention was directed to nonradiological issues over which the AEC has no regulatory jurisdiction, such as thermal effects and antitrust matters.

● Actions to simplify AEC materials licensing included expansion of broad licenses for research and development; issuance of several new general licenses, including ownership of special nuclear materials; and proposals to exempt certain classes of products containing radioisotopes, and small quantities of radioisotopes.

● Colorado and Idaho became the 18th and 19th States to enter into agreements with the AEC to assume regulatory authority over certain atomic energy materials. About 41 percent of the nearly 16,000 materials licenses in effect in the United States are now controlled by States having such agreements with the AEC.

● For the second year in a row, the insurance pools providing private nuclear energy liability insurance paid refunds to policyholders under a retrospective rating plan based on loss experience over a 10-year period.

● The AEC adopted a schedule of fees to be charged for: (*a*) licenses to construct and operate nuclear facilities; (*b*) licenses for radioisotopes of 100,000 curies or more in sealed sources; (*c*) licenses for special nuclear material in quantities sufficient to form a critical mass; and (*d*) certain waste disposal licenses. Certain exceptions from license fees were provided.

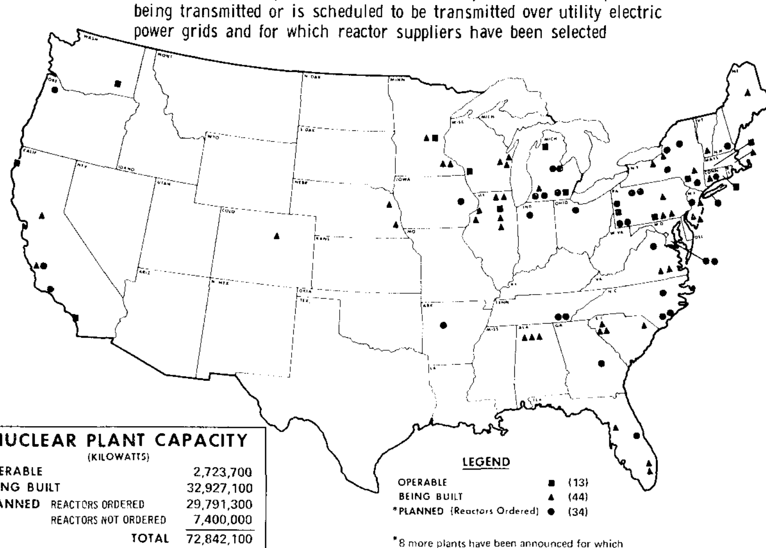
● A survey of injury frequency and severity rates again showed a favorable record of the atomic energy industry compared with recent averages for all manufacturing industries reporting to the Bureau of Labor Statistics.

Operational Safety

● Early this year, the AEC and its contractors were presented with the National Safety Council's Award of Honor for 1967 (the sixth such award received in as many years) for the safest year in the AEC's history. However, the 1968 safety record has proven to be even better than that of 1967 with fewer fatalities and a lower frequency of injuries.

NUCLEAR POWER PLANTS IN THE UNITED STATES

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



NUCLEAR PLANT CAPACITY (KILOWATTS)

OPERABLE		2,723,700
BEING BUILT		32,927,100
PLANNED	REACTORS ORDERED	29,791,300
	REACTORS NOT ORDERED	7,400,000
	TOTAL	72,842,100

ELECTRIC UTILITY CAPACITY BY CONVENTIONAL MEANS AS OF SEPTEMBER 30, 1968 284,341,314 KILOWATTS

U.S. Atomic Energy Commission
December 31, 1968

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT

[In Operation, Under Construction, or Planned]

Plant	Capacity [1] (net Mwe.)	Utility/owner	Startup
Alabama:			
Browns Ferry Nuclear Power Plant:			
Unit 1	1,065	TVA	1970
Unit 2	1,065	do	1971
Unit 3	1,065	do	1972
Arkansas:			
Russellville Nuclear Unit	825	Arkansas Power & Light Co	1972
California:			
Malibu Nuclear Plant: Unit 1 [2]	462	Los Angeles Department of Water & Power.	1973
Diablo Canyon Nuclear Power Plant:			
Unit 1	1,060	Pacific Gas & Electric Co	1971
Unit 2	1,070	do	1974
Humboldt Bay Power Plant: Unit 3	68	do	1963
Rancho Seco Nuclear Generating Station	800	Sacramento Municipal Utility District.	1973
San Onofre Nuclear Generating Station	430	*Southern California Edison, San Diego Gas & Electric Co.*	1967
Colorado:			
Fort St. Vrain Nuclear Generating Station	330	*Public Service Co. of Colorado*	1972
Connecticut:			
Connecticut Yankee Atomic Power Plant	462	Connecticut Yankee Atomic Power Co.	1967
Millstone Nuclear Power Station:			
Unit 1	549	Millstone Point Co	1969
Unit 2	828	do	1973
Florida:			
Crystal River Plant: Unit 3	825	Florida Power Corp	1972
Hutchinsons Island	800	*Florida Power & Light Co*	1973
Turkey Point Station:			
Unit 3	652	do	1970
Unit 4	652	do	1971
Georgia:			
E. I. Hatch Nuclear Plant	786	Georgia Power Co	1972
Illinois:			
Dresden Nuclear Power Station:			
Unit 1	200	Commonwealth Edison Co	1959
Unit 2	715	do	1969
Unit 3	715	do	1970
Quad-Cities Station:			
Unit 1	715	Commonwealth Edison, Iowa-Illinois Gas & Electric Co.	1970
Unit 2	715	do	1971
Zion Station:			
Unit 1	1,050	Commonwealth Edison Co	1972
Unit 2	1,050	do	1973
Indiana:			
Bailly Generating Station	515	Northern Indiana Public Service Co.	1973
Iowa:			
Duane Arnold Energy Center: Unit 1	538	Iowa Electric Light Power Co.	1973
Maine:			
Maine Yankee Atomic Power Plant	790	Maine Yankee Atomic Power Corp.	1972
Maryland:			
Calvert Cliffs Nuclear Power Plant:			
Unit 1	800	Baltimore Gas & Electric Co	1972
Unit 2	800	do	1973

See footnotes at end of table.

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Continued

Plant	Capacity [1] (net Mwe.)	Utility/owner	Startup
Massachusetts:			
Pilgrim Station	625	Boston Edison Co	1971
Yankee Nuclear Power Station	175	Yankee Atomic Electric Co	1960
Michigan:			
Big Rock Point Nuclear Plant	70	Consumers Power Co	1962
Donald C. Cook Plant:			
Unit 1	1,054	Indiana & Michigan Electric Co	1972
Unit 2	1,054	do	1973
Enrico Fermi Atomic Power Plant	61	Power Reactor Development Corp.	1963
Midland Nuclear Power Plant:			
Unit 1	663	Consumers Power Co	1973
Unit 2	663	do	1974
Palisades Nuclear Power Station	700	do	1970
Unnamed	1,100	Detroit Edison Co	1974
Minnesota:			
Elk River Nuclear Plant	22	Rural Coop. Power Association & AEC.	1962
Monticello Nuclear Generating Plant	472	Northern States Power Co	1970
Prairie Island Nuclear Generating Plant:			
Unit 1	530	do	1972
Unit 2	530	do	1974
Nebraska:			
Cooper Nuclear Station	778	Consumers Public Power District	1971
Fort Calhoun Station: Unit 1	457	Omaha Public Power District	1970
New Hampshire:			
Seabrook Nuclear Station	860	Public Service Co. of New Hampshire.	1974
New Jersey:			
Oyster Creek Nuclear Power Plant:			
Unit 1	515	Jersey Central Power & Light Co	1969
Unit 2	810	do	1973
Salem Nuclear Generating Station:			
Unit 1	1,050	Public Service Electric & Gas Co., Philadelphia Electric Co., ACEC, & Delmarva P. & L. Co.	1971
Unit 2	1,050	do	1972
New York:			
Bell Station	838	New York State Electric and Gas Corp.	1973
Indian Point Station:			
Unit 1	265	Consolidated Edison Co	1962
Unit 2	873	do	1970
Unit 3	965	do	1971
Nine Mile Point Nuclear Station	500	Niagara Mohawk Power Corp	1969
R. E. Ginna Nuclear Power Plant: Unit 1	420	Rochester Gas & Electric Co	1969
Shoreham Nuclear Power Station	800	Long Island Lighting Co	1975
Unnamed	1,115	Consolidated Edison Co., Orange & Rockland Utilities, Inc.	1973
John A. FitzPatrick Nuclear Power Plant	815	Power Authority of State of New York.	1973
North Carolina:			
Brunswick Steam Electric Plant:			
Unit 1	821	Carolina Power & Light Co	1974
Unit 2	821	do	1973
Unnamed	821	do	1976
Ohio:			
Davis-Besse Nuclear Power Station	800	Toledo Edison Co. and Cleveland Electric Illuminating Co.	1974

See footnotes at end of table.

TABLE 1—CENTRAL STATION NUCLEAR POWERPLANTS UNDER CONTRACT—Continued

Plant	Capacity[1] (net Mwe.)	Utility/owner	Startup
Oregon:			
Trojan Station	1,100	Portland General Electric Co.	1974
Pennsylvania:			
Beaver Valley Power Station: Unit 1	847	Duquesne Light Co. & Ohio Edison Co.	1973
Peach Bottom Atomic Power Station:			
Unit 1	40	Philadelphia Electric Co.	1966
Unit 2	1,065	Philadelphia Electric Co., Public Service Electric & Gas Co., ACEC, & Delmarva P. & L. Co.	1970
Unit 3	1,065	do	1972
Shippingport Atomic Power Station: Unit 1	90	Duquesne Light Co. & AEC	1957
Three Mile Island Nuclear Station	831	Metropolitan Edison Co.	1970
Unnamed	1,052	Pennsylvania Power & Light Co.	1975
Do	1,052	do	1977
Do	1,065	Philadelphia Electric Co.	1975
Do	1,065	do	1977
South Carolina:			
H. B. Robinson S.E. Plant: Unit 2	700	Carolina Power & Light Co.	1970
Oconee Nuclear Station:			
Unit 1	839	Duke Power Co.	1970
Unit 2	839	do	1971
Unit 3	839	do	1972
Tennessee:			
Sequoyah Nuclear Power Plant:			
Unit 1	1,129	TVA	1973
Unit 2	1,129	do	1973
Vermont:			
Vermont Yankee Generating Station	514	Vermont Yankee Nuclear Power Corp.	1970
Virginia:			
North Anna Power Station: Unit 1	800	Virginia Electric Power Co.	1974
Surry Power Station:			
Unit 1	783	do	1970
Unit 2	783	do	1971
Washington:			
N-Reactor/WPPSS Steam[3]	790	Washington Public Power Supply System (WPPSS).	1966[3]
Wisconsin:			
Kewaunee Nuclear Power Plant: Unit 1	527	Wisconsin Public Service Co., Wisconsin P. & L. Co., and Michigan Gas & Electric Co.	1972
LaCrosse Boiling Water Reactor	50	Dairyland Power Coop. & AEC	1967
Point Beach Nuclear Plant:			
Unit 1	455	Wisconsin Electric Power Co	1970
Unit 2	455	do	1971

[1] Electrical capacities are the initial operating power levels as indicated in the construction applications or in the permits for plants under construction or review, and the currently authorized power levels for plants now in operation.

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

[3] The Nation's first dual-purpose reactor plant; steam created in the AEC's plutonium producing "N" reactor is drawn off for use in the adjacent WPPSS electric power generators—as such, this facility is not in the same category as the other plants listed in this table. Single-purpose plutonium production started in 1963; electricity generation began on November 29, 1966.

● A series of 3-day seminars on "Planning for Medical Care and Treatment for Radiation Victims" was conducted by the AEC to familiarize physicians who provide medical services to licensees and those physicians associated with cooperating community hospitals to familiarize them with the diagnosis and treatment of radiation injuries. National experts in medical care related to radiation problems and AEC and AEC contractor personnel provide the training.

Nuclear Rocket Propulsion

● Preliminary planning and design for the development of the NERVA engine (75,000-pound-thrust) continued. Major activities included determination of engine requirements, evaluation of design alternatives, and preliminary design studies.

● In April, cold-flow tests were successfully completed on the first ground-experimental engine (the XECF) at the Nuclear Rocket Development Station (NRDS) in Nevada using the recently-activated Engine Test Stand No. 1. The power testing of the ground-experimental engine (XE) began in December when the engine's reactor achieved criticality (ability to sustain a fissioning reaction) and was operated at low-power levels to calibrate nuclear instrumentation.

● On June 26, the Phoebus–2A reactor, the twelfth nuclear rocket reactor to be tested by the Los Alamos Scientific Laboratory at the NRDS, was operated for about 12 minutes at power levels above 4,000 Mw. (4,200 Mw. peak power). This was a new AEC record in reactor power.

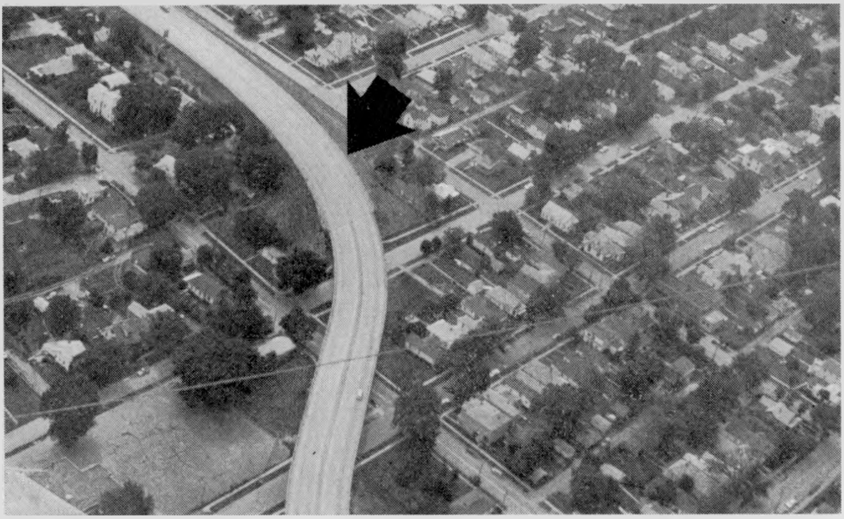
● On December 4, the Pewee–1 reactor test series was successfully completed in an experimental run that lasted over one hour. This reactor achieved a higher power density and higher temperature than any reactor tested to date.

Specialized Nuclear Power Units

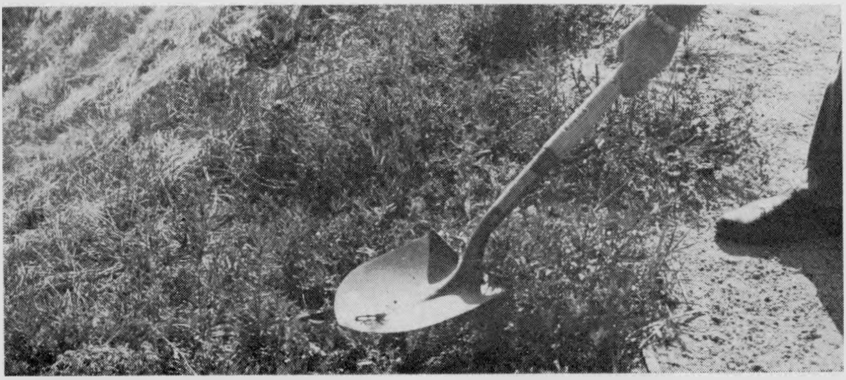
● Conceptual design studies have been completed of implantable radioisotope engines to supply mechanical power for small pumps which would assist or replace the functions of a diseased or damaged heart. All of the concepts studied appear feasible; *i.e.*, they can be developed within the limits of the currently available technology.

● Development of five operational SNAP–27 generators was completed except for final qualification testing. The generators are to be delivered to NASA for use in Apollo lunar missions.

● In June 1968, a SNAP–3A unit—the first orbited—entered its eighth year of operation in space, more than 2 years beyond its 5-year design life expectancy.



Locating a Lost Radioactive Source was, for the first time known, done with an airplane during June. Somewhere between Salt Lake City, Utah, and Kansas City, Mo., a radiocobalt source belonging to an AEC licensee rolled out of its overturned shipping cask. The source was not in the truck or terminal. The question was "where?" The interstate carrier alerted the AEC and a special AEC aircraft was pressed into service. Working eastward, it retraced the 1,100-mile route flying 500 feet above the highway. Its sensitive instruments sorted out natural radiation. As the plane passed over a bend in the highway at St. Joseph, Mo., a sudden rise and fall of the needle indicated manmade radioactivity (see arrow in photo *above*). The plane landed at the nearest airport and the crew went to the site. The cobalt-60 source, 2 inches by one-half inch (shown on shovel *below*), was located by hand meter—2 feet down the highway embankment—and placed in a shielded container. It was turned over to AEC. The tiny 325-millicurie source would not have endangered passersby unless pocketed and carried for a few hours. The Aerial Radiological Measuring System (ARMS) plane, used in AEC biomedical research, is operated for the AEC by E.G. & G., Inc., Las Vegas, Nev. The lost source was found within 3½ days of the request for help, and less than 48 hours after the "ARMS" plane was airborne. Such radiological assistance is administered under the AEC operational safety program.



● Two plutonium–238 capsules were recovered from the SNAP–19 generators on board a submerged Nimbus–B weather satellite which failed to orbit because of a guidance malfunction in the NASA Thorad-Agena–D booster vehicle.

● Significant progress has been made in the development of a 2,000° F. plutonium–238 fuel capsule for the large heat source program.

Isotopic Radiation Applications

● Efforts at Brookhaven National Laboratory to use stable isotopes of sulfur to study the atmosphere distribution and state of sulfur dioxide from stacks of fossil-fueled plants have provided necessary background data and monitoring equipment preparatory to initiation of field trials.

● Development of radiation processed concrete-polymer composites as an improved material of construction is the objective of a joint program involving the AEC and the Department of Interior's Bureau of Reclamation and Office of Saline Water.

The Plowshare Program

● Three cratering experiments were conducted during 1968 under the Peaceful Nuclear Explosives (Plowshare) program. One of them was the first nuclear row charge experiment to be conducted in developing an excavation technology for large-scale earth-moving projects such as canals and harbors.

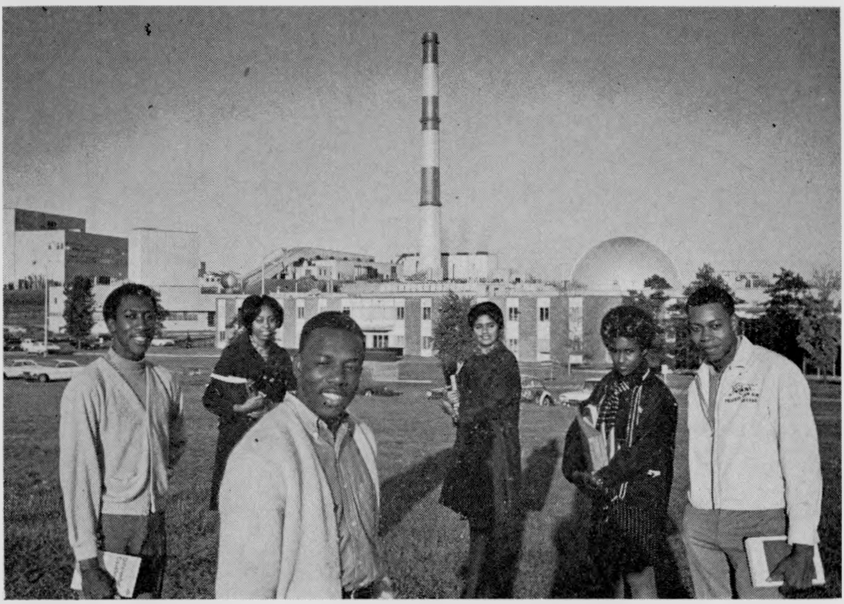
● A contract for a joint industry-Government underground engineering experiment is under negotiation by CER Geonuclear Corp., the Department of Interior, and the AEC for an experiment to investigate the use of nuclear explosives to aid in the recovery of oil from oil shale.

International Cooperation Activities

● Agreements for Cooperation were amended and extended to provide for the long-term supply of enriched uranium fuel for power reactors to countries planning nuclear power programs. Contracts for toll enrichment services whereby privately owned uranium will be enriched in uranium–235 in AEC facilities for a service charge were signed with a number of foreign parties.

● Studies continued on the use of nuclear power reactors for the dual purpose of water desalting and electricity production. A United States-Mexico-IAEA group concluded a study on the feasibility of such a large dual-purpose plant on the Gulf of California. Another group undertook a study of the potential of nuclear powered agro-industrial centers in the Middle East as a means of helping to overcome the chronic shortage of water and power in that area.

● As of mid-1968, the AEC had distributed abroad through sale and lease, and deferred payment sales, special nuclear and other materials valued at approximately $313.3 million, resulting in revenues to the United States of $221.8 million.



A New Approach to Education is being tried out by an AEC National Laboratory. Classes started on the "Brookhaven Campus" in September under a National Science Foundation grant of $57,000. The educational concept is unique in four major ways: (*a*) it provides for two faculty members per year and six students per semester from the participating colleges to spend their academic year in residence at Brookhaven National Laboratory, Upton, Long Island, N.Y.; (*b*) it provides for the students to receive full credit the same as they would on their own campus; (*c*) it is aimed entirely at 10 participating universities and colleges; and (*d*) it provides an opportunity for Brookhaven scientists to contribute directly to the educational process at each of the member schools. The 10 participating, primarily Negro colleges are: Miles College, Tuskegee Institute, and Talladega College, in Alabama; Grambling College in Louisiana; Tougaloo College in Mississippi; Langston University in Oklahoma; Prairie View A. & M. College, Texas College, and Jarvis Christian College, in Texas; and Knoxville College in Tennessee. The six students (*above*) attended the fall semester and represented four of the participating southern colleges which have formed a Regional Cooperative Association in Sciences and Mathematics.

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Informational and Related Activities

- The AEC's domestic film libraries loaned popular and professional-level films on atomic energy subjects for 104, 313 showings. During the year, 13 new motion pictures were added to the film library system. Two AEC films—"Guardian of the Atom" and "The Day Tomorrow Began"—were selected for international Golden Eagle Awards by the Council on International Nontheatrical Events (CINE).
- The first in a series of radio programs, "Let's Talk About the Atom," was produced and offered to commercial and educational broadcasters in the United States.
- A collection of black and white and color slides was made available to science teachers and to AEC and contractor speakers as visual aids.
- Initial steps were taken to reduce the number of overseas depository libraries to one per country as an economy measure. Such libraries receive free distribution of AEC reports
- Seven new booklets were added to AEC's "Understanding the Atom" series.
- In 1968, over 70 "AEC–NASA Tech Briefs" were issued raising the total number of these popular summaries to about 240.
- Highlights of the AEC exhibits program included five major overseas presentations in Taiwan, Korea, Venezuela, Mexico, and Argentina.
- AEC demonstrations and exhibits in the United States were seen by more than 7 million viewers.
- As a result of a recent comprehensive survey of AEC classification policy, classification in some areas of special significance to the national defense and security was reaffirmed but many additional areas of information were declassified. Approximately 10,000 documents were declassified and made available to science and industry.
- The AEC was granted 231 United States and 426 foreign patents during the year. Nine public announcements were issued by the AEC listing new United States and foreign patents as they were collated. The Commissioner of Patents referred privately owned patent applications in the atomic energy field to the AEC for review. Some 162 nonexclusive licenses were granted on U.S. patents and patent applications available for licensing.

Nuclear Education and Training

- During 1968, the AEC's nuclear training programs continued to feature educational assistance in graduate education in nuclear specialities, a wide variety of educational and training programs, and grants to academic institutions for nuclear equipment.

- Programs administered for the AEC by the Associated Midwest Universities have become part of the policy responsibilities of the Argonne Universities Association to permit a closer cooperative relationship between the educational community and Argonne National Laboratory research programs. Formation of the Argonne Center for Educational Affairs strengthened that cooperation.
- During 1968, there were nearly 5,000 graduate students employed in life and physical sciences research under AEC contracts.

Biomedical and Physical Research

- Additions have been made to biomedical facilities at the Brookhaven Medical Center to provide space for the care, treatment, and observation of laboratory animals, and service rooms for maintaining the necessary sanitary conditions.
- Laboratory and office buildings have been completed at the AEC's biomedical research project at Lawrence Radiation Laboratory, Livermore. The project seeks to advance human knowledge of the biological implications of radiation as they affect man.
- The 33 billion electron volt (Bev.) Alternating Gradient Synchrotron (AGS) is undergoing a major conversion to increase beam intensity. This is being accomplished by replacing the 50 million electron volt (Mev.) linear accelerator injector with one having an energy of 200 Mev., and by augmenting the main AGS magnet power supply.
- Funds in the amount of $14.6 million were provided to begin construction of the National Accelerator Laboratory at Batavia, Ill. (The principal scientific instrument at the laboratory will be the 200 Bev. proton synchrotron.) Initial construction contracts were awarded in late 1968 and groundbreaking ceremonies were held on December 1.

Industrial Participation

- New manufacturing facilities to supply components or services for nuclear powerplants were under construction at more than 15 sites at an estimated cost of more than $250 million.
- AEC-Justice Department discussions on competition in the nuclear power supply industry led to an Arthur D. Little, Inc., study and report on each segment of the industry and its competitive aspects. This study, the first of its type, was designed to obtain economic and structural information on an industry still in the formative stages of development.

This Macaque Monkey, who is known as "Nancy" to the staff at Los Alamos Scientific Laboratory (LASL), gave birth to a normal offspring in spite of having previously been exposed to a normally lethal dose of 1,528 *rads* of gamma radiation. She was irradiated during tests on the possible effects of radiation on space travellers, conducted in 1964 by LASL in cooperation with the Air Force Aeromedical Research Laboratory at Holloman Air Force Base, Alamogordo, N. Mex. Her baby, called "Chancy," was born December 7, 1967. There are relatively few cases on record where a mammal has received such a large radiation dose and reproduced. This would indicate that individual animals differ widely in their resistance to radiation damage, and apparently some females remain fertile after being exposed to radiation levels which are lethal to others.

Administrative and Management Matters

● The many uses of nuclear energy continue to have a significant impact on the Nation's economy. An employment survey shows that in mid-1968, some 141,700 persons were working in the atomic energy field as compared to the 136,500 so employed in 1967.

● Participation by AEC contractors in the President's Youth Opportunity Campaign increased significantly. Over 1,200 disadvantaged youths were hired for the summer of 1968 compared to 860 in 1967.

● Diversification and expansion of the economic base of the Richland, Wash., area continued. New privately owned diversification facilities under construction by AEC contractors are a resort and convention center, cattle feedlot, and the second addition to a major laboratory facility. A privately constructed zirconium tube fabrication plant was completed during the year.

● A demonstration of the advantage of using warm reactor cooling water for irrigation was proposed at the Hanford Works in Washington. Water from the "N" reactor would be used to conduct a 4-year farming experiment that could lead to a practical method for utilizing the waste heat discharged into rivers from nuclear powerplants.

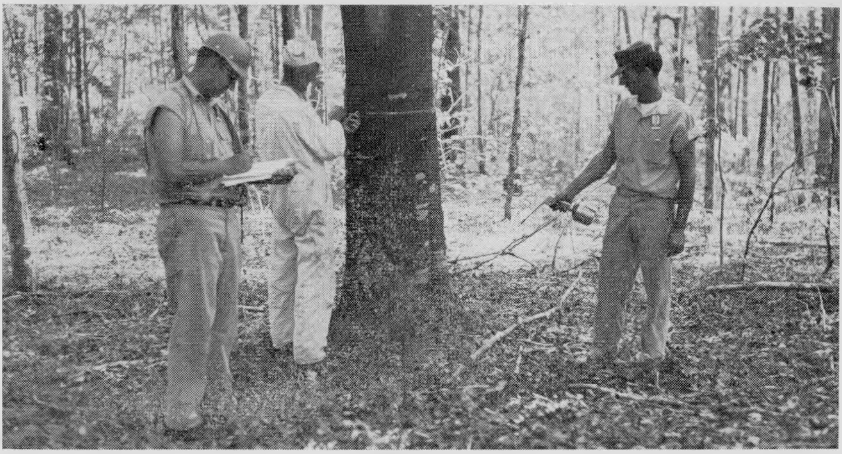
● On December 19, the AEC published in the *Federal Register* an amendment to 10 CFR Part 20 implementing a radiation exposure recordkeeping system with AEC contractors which are exempt from licensing and certain licensees conducting industrial type activities involving the handling of substantial quantities of radioactive material. The AEC has also approved the establishment of a pilot recordkeeping system with a limited number of States for the reporting of summary exposure information on radiation workers to a central repository.

● The AEC has met with representatives of interested State and private organizations in the major uranium-producing States to determine their interest in the establishment of a pilot recordkeeping system. The results of these meetings indicate that the system should be limited initially to the reporting of uranium miner exposure information. Such a system would, among other things, provide a mechanism for tracing the exposures of uranium miners employed in more than one State

● Five States enacted legislation in 1968 covering one or more of the AEC's recommended workmen's compensation standards for radiation workers.

● A new "performance fee" concept has been made part of an AEC contract. The concept is designed to overcome problems experienced with cost-plus-incentive fee research and development or operating contracts.

● During fiscal 1968, AEC prime contractors awarded over 45 percent of the subcontracts to small business concerns. AEC assistance to small business has been averaging 42 percent of subcontract awards during the period 1951 through 1968.



Forest Management of the Timberland—100,000 acres of it—surrounding the Oak Ridge National Laboratory, Tenn., and the Savannah River Plant, S.C., is being put to good use by the AEC. Over 70,000 acres in Barnwell and Aiken Counties, S.C., and over 20,000 acres in Roane and Anderson Counties, Tenn., have been placed under active forest management programs. Ecologists at ORNL (*above*) measure tree volume and mark trees with paint for cutting. The logging team (*below*) removes timber from the forest management area. As a result of the controlled and selective cutting, the AEC expects to improve the yield and assure a higher quality of lumber for marketing. The annual harvest from both reservations is roughtly 20 million board feet of saw timber and 35,000 cords of pulpwood. AEC's income from such sales has already reached the $2.5 million mark—a sizable fraction of, and an unexpected return on, the Government's initial investment in the land. The Savannah River land management program operates under an agreement between the AEC and the U.S. Forest Service. The Oak Ridge forest management program involves the AEC, Tennessee Valley Authority, the City of Norris, and commercial lumbering concerns. Cutting is prohibited in certain "control" areas which are being used to compare the effectiveness of the management program or to conserve typical Appalachian ridge and Tennessee Valley landscapes.

Chapter 1

SOURCE, SPECIAL, AND BYPRODUCT NUCLEAR MATERIALS

URANIUM SUPPLY

The continued interest in nuclear powerplants, as evidenced by the new orders for reactor units, has provided a substantial commercial base for the uranium mining and processing industry. Exploration activity expanded to record levels during the year. The expansion of several mining and milling facilities was undertaken, and plans for several new mills were announced by industry.

RAW MATERIALS

During 1968, the AEC purchased from domestic producers 7,300 tons of U_3O_8 in uranium concentrate under existing contracts out of a total production of 12,300 tons. In 1969 and 1970, the price the AEC will pay to each contractor will be related to its cost of production during 1963–68, but will be no more than $6.70 per pound maximum, as compared with the price of $8 which has prevailed since April 1962.

Procurement by Industry

Additional industrial commitments for commercial uranium sales were made during 1968. It is indicated that a total of 67,500 tons of U_3O_8 have been sold, or are now committed for sale, to domestic purchasers.

Some 3,200 tons of U_3O_8 are estimated to be committed to foreign buyers. The domestic nuclear power industry has obtained all of its requirements for enriched uranium through 1968 by lease from the AEC, and also plans to lease from AEC a significant proportion of requirements in 1969 and 1970. General distribution by the AEC of power reactor fuels under lease will terminate December 31, 1970.

TABLE 1.—PROJECTED COMMERCIAL URANIUM REQUIREMENTS AND SALES

[Commitments by year of delivery in tons of U_3O_8]

Year	Domestic sales and commitments		Projected domestic requirements [1] (cumulative)
	Annual	Cumulative	
Pre-1968	900	900	3,800
1968	4,600	5,500	7,800
1969	5,200	10,700	13,400
1970	7,200	17,900	20,900
1971	10,200	28,100	30,100
1972	10,700	38,800	42,600
1973	9,700	48,500	57,000
1974	7,700	56,200	72,000
1975–77	11,300	67,500	245,000

[1] Requirements each year include initial fuel for new reactors and makeup fuel for operating reactors, the latter varying from about 15 percent of total annual requirements in 1968 to about 60 percent in 1980. Fuel processing times are assumed and reactor characteristics supplied by reactor manufacturers are used. The tails assay in the uranium enrichment plants is taken as 0.2 percent uranium-235. Plutonium recycle in thermal reactor is assumed to start in 1974, reducing annual requirements for U_3O_8 by about 2 percent in 1973 to 12 percent in 1980.

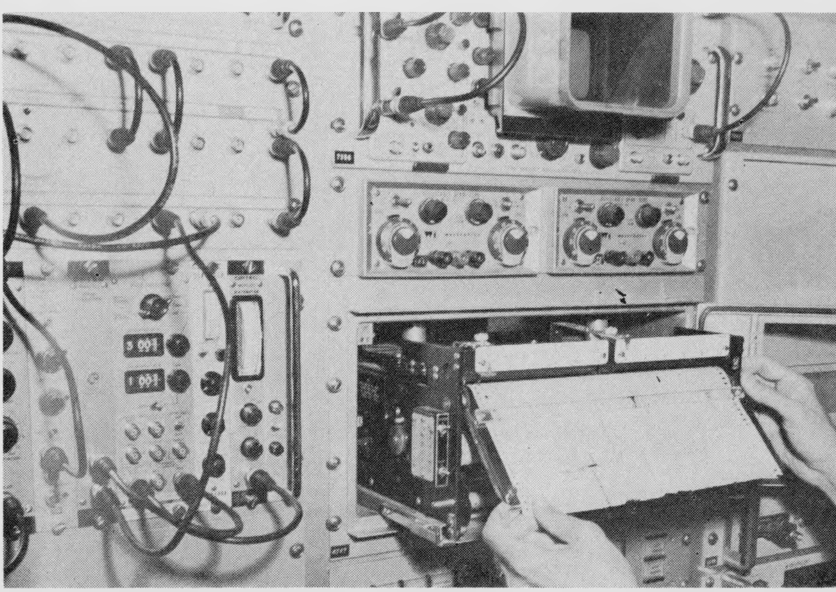
Substantial additional sales commitments will be needed to meet projected nuclear power requirements for delivery in the middle 1970's and beyond. The uranium producing industry is taking steps to meet these requirements. Capacity of three uranium mills has been expanded. United Nuclear Corp. plans to build a new mill in the Churchrock, N. Mex., area, where a shaft is being sunk to open a new mine. Kerr-McGee Corp. is considering building a new mill in the Powder River Basin, Wyo., and is expanding its Grants, N. Mex., facility. In the Shirley Basin, Wyo., Utah Construction and Mining Co. has announced plans for construction of a new mill and Petrotomics plans a mill expansion.

Ore Reserves

The U.S. uranium ore reserve situation changed during 1968 as follows:

	Tons of ore	Percent U_3O_8	Contained tons U_3O_8
Reserves Jan. 1, 1968	64,000,000	0.23	148,000
Reserves Dec. 31, 1968	70,000,000	0.23	161,000
Increase during 1968	6,000,000	0 21	13,000

Evaluation of Uranium Deposits is usually done with data obtained by measuring the radioactivity in holes drilled through the ore zones. Photo *above* shows an AEC hole-logging truck at calibration holes near Casper, Wyo. These holes, which were drilled by the AEC, provide the mining companies and logging service companies with a common point of reference for calibrating and comparing logging equipment. The radiation measured in a hole drilled through a uranium deposit is recorded on paper "strip" logs such as that shown in photo *below* of the interior of an AEC logging truck. By analysis of the log an estimate of the thickness and grade of the material encountered in the hole can be made. In addition to measurements of gamma radioactivity, for geologic purposes measurements are frequently made of rock resistivity or other characteristics.



During the year, an estimated 26,000 tons of U_3O_8 were added to the known $8 reserves. As 13,000 tons in ore were mined and shipped to mills during the year and hence removed from reserves, there was a net increase in reserves of 13,000 tons at the end of the year. This is the largest net addition to reserves since 1959 and is a reflection of the increased exploration activity of the last few years.

These estimates represent reasonably assured reserves considered to be economically recoverable at $8 per pound of U_3O_8 or less. At $10 per pound, reserves are estimated to be 320,000 tons of U_3O_8, including 120,000 tons estimated available as a byproduct from production of copper and phosphate through the year 2000. In addition to these reserves, uranium industry inventories at the end of the year included 750 tons of U_3O_8 in ore stockpiles at the mills and 4,200 tons in process and in finished product for a total inventory of 4,950.

Some additional uranium discoveries and developments were made during the year which are not yet sufficiently delineated to be reflected in the AEC estimates of reserves. The large industry exploration effort now underway is expected to add substantially to reserves in the years ahead.

Exploration Activity

The magnitude of the private exploration activity in the United States is indicated by the 23.8 million feet of drilling performed during 1968—well over twice the 10.7 million feet drilled in 1967 and the 9 million feet drilled in the peak year of exploration in the 1950's. Although a substantial portion of the exploration effort is in areas with known uranium deposits, there is increasing activity in areas previously unexplored and remote from existing production facilities. A number of additional companies, including several oil companies, entered the uranium exploration business during the year. Industry reported plans to continue drilling about 25 million feet per year in 1969 and 1970. The chart, "U.S. Uranium Exploration and Reserve Additions, U_3O_8 Sales and Orders" shows the historical and planned drilling activity of the uranium mining industry, additions to reserves, and purchases and orders for uranium concentrates by the AEC and commercial buyers.

Resource Research

Projected future uranium requirements are considerably larger than the total of currently estimated reserves and additional resources at less than $10 per pound in known favorable geologic environments.

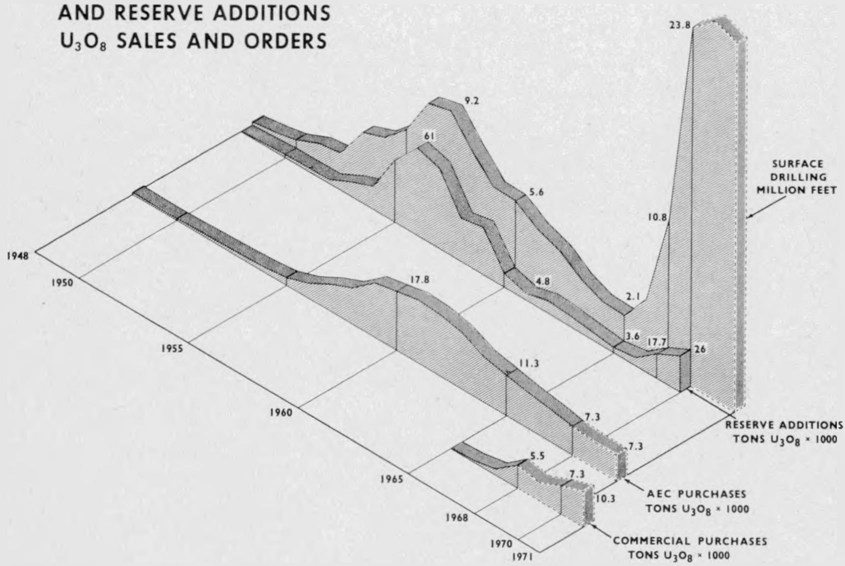
Future requirements may have to be met in large part from areas and environments not now recognized as favorable for uranium exploration. To help foster timely development of new resources, the AEC sponsored a research program, which was carried out by universities and research groups, for developing basic knowledge on the mechanism of formation and characteristics of uranium deposits and to improve exploration technology.

Byproduct Resources

At some copper mines in the United States, where waste dumps are leached with dilute acid to recover additional copper, the leach solutions have been found to contain traces of uranium. A new type of ion exchange column has been developed by the U.S. Bureau of Mines at Salt Lake City, Utah, which appears suitable for recovery of uranium from these solutions.

Uranium is also present in low concentrations in the phosphate rock mined in Florida for production of fertilizers. Byproduct uranium was recovered in several phosphate plants in the late 1950's. Production is expected to be resumed when market conditions warrant.

U.S. URANIUM EXPLORATION
AND RESERVE ADDITIONS
U_3O_8 SALES AND ORDERS



Raw Materials Policy

On September 7, 1968, the AEC published in the *Federal Register* a revised statement of policies relating to uranium supply through June 30, 1973. In the statement, the AEC reaffirmed its preference for toll enrichment in AEC facilities of privately owned uranium as the means for commercial users of enriched uranium to obtain their needed supplies. However, the AEC is willing to sell Government-owned uranium on a single transaction basis, generally in the form of natural uranium, in instances where a prospective purchaser has been unable to obtain uranium commercially on the required time schedule, or at a price not exceeding that being used as a basis for the AEC charge. AEC sales of enriched uranium will, in general, be limited to situations in which rapid delivery is required to meet unforeseen emergencies, where small quantities are involved, or where the material to be purchased is already held on lease from the AEC. The price will continue to be based on $8 a pound of U_3O_8 in concentrates, but consideration will be given to escalation of this price if conditions warrant. Terms and conditions of any sales of Government-owned uranium to meet a requirement for enriched uranium to be delivered after June 30, 1973, will be established and announced before that date.

The *Federal Register* notice stated that at the present time removal of restrictions on enrichment of foreign uranium intended for use in a domestic facility appeared possible by June 1973, or earlier. The AEC also indicated that it would consider the possibility of removing such restrictions on a graduated scale, and that it would announce a proposed date for removal as early as possible.

URANIUM ENRICHMENT

The AEC has continued its study of the feasibility and desirability of a private commercial service for enrichment [1] of uranium. The study concerns the possible transfer of the Government-owned plants to private industry and, alternatively, whether Federal operation should be continued in the best interests of the nation. The study covers the possible construction of new plants as well as operation of the existing plants. The enrichment function which is presently performed by the AEC's three contractor-operated gaseous diffusion plants (Oak Ridge,

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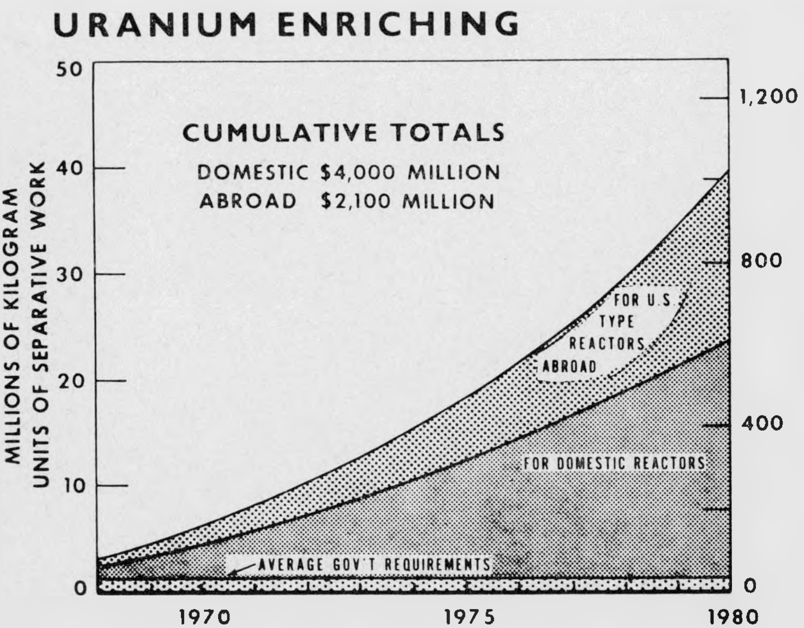
[1] In the enrichment process, uranium hexafluoride (UF_6), in a gaseous state, is passed through a series of barriers to partially separate the lighter and faster-moving uranium-235 (U^{235}) atoms from the heavier and slower-moving uranium-238 atoms which make up the bulk of the material. The greater concentration of U^{235} enhances the fissionability of the end product making it more useful as nuclear reactor fuel.

Tenn.; Portsmouth, Ohio; and Paducah, Ky.) initially was done primarily for weapons purposes. However, enrichment operations are, and will be, increasingly devoted to producing nuclear power reactor fuel as indicated in the chart "Uranium Enriching" (the left and right columns of the chart are on a "per year" basis).

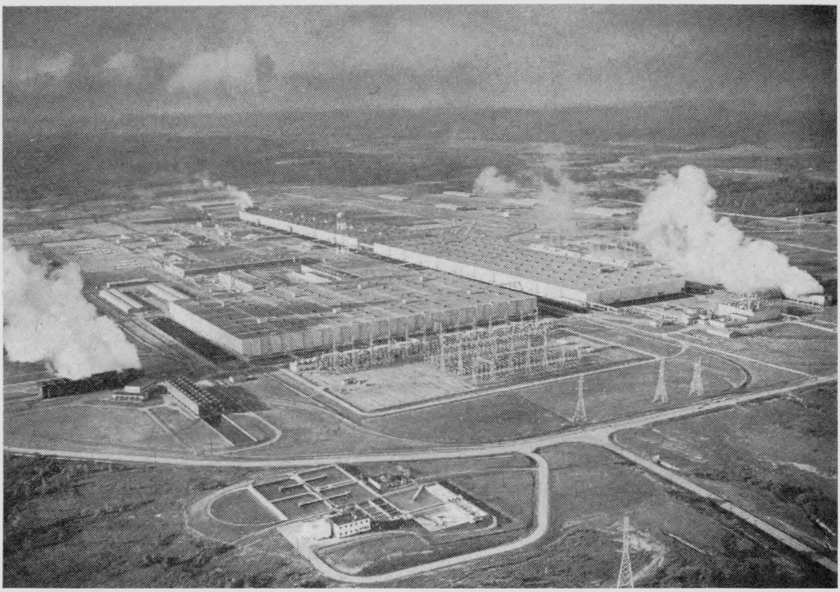
An Atomic Industrial Forum (AIF) committee issued a report in mid-1968 which concluded that it is feasible and desirable for the AEC to transfer its enrichment plants promptly to the industrial sector. The uranium enrichment topic is expected to be a subject of future public hearings before the Congressional Joint Committee on Atomic Energy.

Toll Enriching Services

Toll enriching services will be available to domestic and foreign customers beginning on January 1, 1969. The Private Ownership of Special Nuclear Materials Act of 1964 authorized the AEC to enter into long-term contracts to provide such services. Since the AEC will continue to distribute, by lease, enriched uranium for use in power reactors through 1970, it is being assumed—for planning purposes—that part of the enriched uranium required for civilian applications during the next 2 years will be provided through toll enriching. As of the end of 1968, the AEC had one contract with a domestic firm and



nine with foreign governments and nationals. The contracts will provide for the enriching of fuel for 11 reactors and vary in term from 1 to 30 years. Toll enrichment services will be performed in the AEC's three gaseous diffusion plants.



The AEC's Portsmouth Gaseous Diffusion Plant, located near Piketon, Ohio, is located on a 4,000-acre tract of land. Its three process buildings cover approximately 220 acres, or 9,650,000 square feet of floor space. When operating at full capacity, the plant is designed to use a water supply of 345 million gallons with a daily makeup of 20 million gallons. Fifteen power companies pooled their resources to organize the Ohio Valley Electric Corp. capable of continuously delivering in excess of 1,800 megawatts of electricity (Mwe.) to the facility.

NUCLEAR MATERIALS PRODUCTION

Special nuclear materials production continued during the year at reduced levels established to meet requirements for military and civilian programs. Studies were continued in preparation for steps to meet the increased enriched uranium demands of the nuclear power industry.

PRODUCTION OPERATIONS

Planning for combined production operations continued. Alternative plans for production operation of gaseous diffusion plant and production reactors have been evaluated to determine the best match of plant capabilities and economics to meet projected demands in the future. These activities have become progressively more important with the increasing complexity of production operations.

Studies are being made to determine the best use of resources to meet the projected requirements for enriched uranium. Projected enriched uranium requirements, primarily for civilian use, can be met with existing gaseous diffusion plants until about 1980, through a combination of power restoration, preproduction, major improvements in the cascades, and a program of electrical uprating which will permit added power usage above the current design levels. However, after exploiting these avenues to their economic maximum, enriching capacity from new facilities will be needed. Contracts with the power suppliers have

The Ball Safety System provides Hanford's "N" reactor with an emergency shutdown capability independent of the reactor's horizontal control rods. The control elements for this system are the small samarium oxide balls shown in front of the operator. Hoppers, each holding 108 balls, are embedded in the biological shield on top of the reactor, each one over a vertical channel through the reactor. The hopper gates, held closed by battery-powered solenoids, are designed to open if any number of "out-of-limits" events occur, pouring the neutron-absorbing balls into the reactor. They absorb so many neutrons that the chain reaction is stopped and the reactor shuts down.

been executed which will increase the average power usage in the gaseous diffusion cascade from 2,000 Mwe. (which level will be reached in 1969) to a total of 4,420 Mwe. by early 1973.

Development of plans for effective utilization of the Hanford (near Richland, Wash.) and Savannah River (near Aiken, S.C.) production reactors continued during the year with primary emphasis on safety and versatility. The latter area of long-range planning concerns improving the capability of the reactors to produce alternative products. Following an analysis of supply and demand for reactor products, a decision was made to shut down two additional production reactors in 1968. Previously scheduled reductions in electric power usage were made at the gaseous diffusion plants.

Reactor Shutdowns

On February 12, 1968, the Hanford "B" reactor—which began operation in 1944 as the world's first plutonium production reactor—was placed in standby status. In addition, the 14-year-old "L" reactor at the Savannah River plant was placed in standby on February 18, 1968. These are the sixth and seventh AEC production reactors to be shut down since early 1964.[2]

Diffusion Plant Power Reductions

During the first half of 1968, power usage levels were the same as during the last quarter of 1967; *i.e.*, a total gaseous diffusion cascade electrical power level of 2,700 megawatts (Mwe.) for the three sites (Portsmouth, Paducah, and Oak Ridge). A scheduled power reduction became effective July 1, 1968, when the Oak Ridge cascade power level was reduced by 380 Mwe. to a level of 500 Mwe., and Paducah power was reduced by 25 Mwe. to a level of 1,215 Mwe. A contract modification negotiated with the Ohio Valley Electric Corp. made permanent, on July 1, 1968, a previous temporary reduction of 120 Mwe. This reduction, plus a further drop of 80 Mwe., advanced by 5 months the date when the Portsmouth power level was to be reduced to 500 Mwe. The three-site cascade power level of 2,215 Mwe. on July 1, 1968, will remain constant through June 30, 1969, when a 215-Mwe. reduction at Paducah will be effective.[3] As a result of the 1968 reductions in power, diffusion plant power costs in 1968 are about $15 million below those for 1967.

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[2] See p. 36, "Annual Report to Congress for 1967."
[3] See pp. 35–36, "Annual Report to Congress for 1967."

Gaseous Diffusion Plant Operations

The gaseous diffusion plant complex continued to operate efficiently. Currently, the Paducah plant product is shipped to the Oak Ridge and Portsmouth plants. Enriched uranium products of various assays are withdrawn from both the Oak Ridge and Portsmouth facilities, but all high assay enriched uranium products are withdrawn from the Portsmouth plant. For the first three-quarters of the year, the depleted uranium streams, or tails, from all of the plants were withdrawn at the same assay. In the last quarter, tails comparable to the target tails assay were withdrawn at Paducah only; tails withdrawn from the Oak Ridge and Portsmouth plants were recycled to Paducah.

Startup of Paducah Feed Plant

On August 1, 1968, the uranium hexafluoride (UF_6) plant at Paducah, which had been placed in standby in 1964, was reactivated to produce additional UF_6 feed for the gaseous diffusion plants. The plant converts to UF_6 the partially depleted uranium trioxide (UO_3) recovered from the production reactor operations at Hanford and Savannah River plants. For the next few years, this material will be needed by the diffusion plants to supplement the normal UF_6 received from toll enriching customers.

Gaseous Diffusion Brochure

During the year, the AEC made publicly available further information on the gaseous diffusion complex. The AEC had announced in June 1967, certain quantitative information relative to the enriched uranium production capacity of the AEC gaseous diffusion plants which had been declassified. Then, in September 1967, the AEC made public its "Table of Toll Enriching Services."[4] To supplement the previously released summary information, a brochure[5] was published in February 1968, providing information in greater detail on the physical features, operating requirements, economics, potential improvements, and capabilities of each of the three gaseous diffusion plants, as well as preliminary estimates of the costs of new plants.

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[4] See pp. 30–31, "Annual Report to Congress for 1967."

[5] "AEC Gaseous Diffusion Plants Operations (ORO–658)," available from U.S. AEC, Division of Technical Information Extension, Post Office Box 62, Oak Ridge, Tenn. 37830, upon request.

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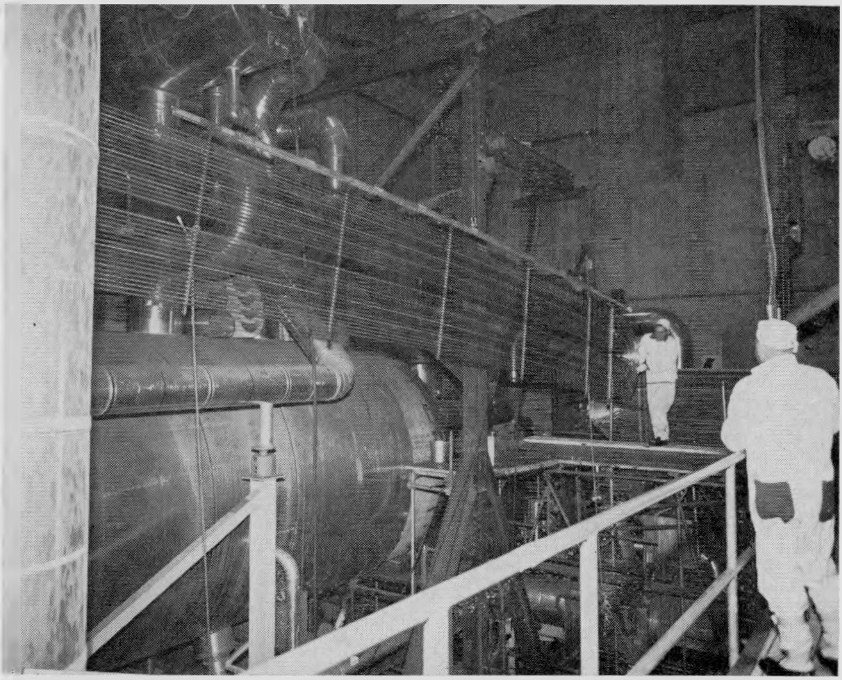
Reactor Operations

The seven operating production reactors—four at Hanford and three at Savannah River—continued to operate at satisfactory levels during 1968.

Hanford Reactors

"N" Reactor Operation. The "N" reactor at Hanford, the nation's first dual purpose reactor, continued to produce special nuclear materials and to make available byproduct steam for generating electricity. Significant gains were made during the year in operating efficiency.



A Complex and Extensive Project to retube 10 of Hanford's "N" reactor's 12 steam generators progressed substantially during the year. Some 20 miles of stainless steel tubing is removed from each steam generator, to be replaced by 20 miles of Inconel tubing. The Inconel has a high nickel content and is much more resistant to stress corrosion than stainless steel. Hot reactor cooling water produces steam in the generators; this steam is used to drive electrical generators at the adjacent Washington Public Power Supply System's plant. This is the first time large steam generators have been decontaminated and retubed in their operational location. The job was made more difficult by the very limited working space at only one end of the generators. The retubing operation was done by the Combustion Engineering Co.; Douglas United Nuclear performed the decontamination, radiation control operations, and final testing of the system.

The demonstration program initiated at the "N" reactor in 1967 to produce tritium and plutonium in the same reactor loading was successfully concluded and the reactor was returned to plutonium production. Satisfactory progress was made during the year on retubing the main heat exchangers. The reactor's entire primary loop system was decontaminated to reduce personnel exposure during maintenance work on the loop system. The technique and the scale on which the decontamination was carried out are unique in the production and power reactor field.

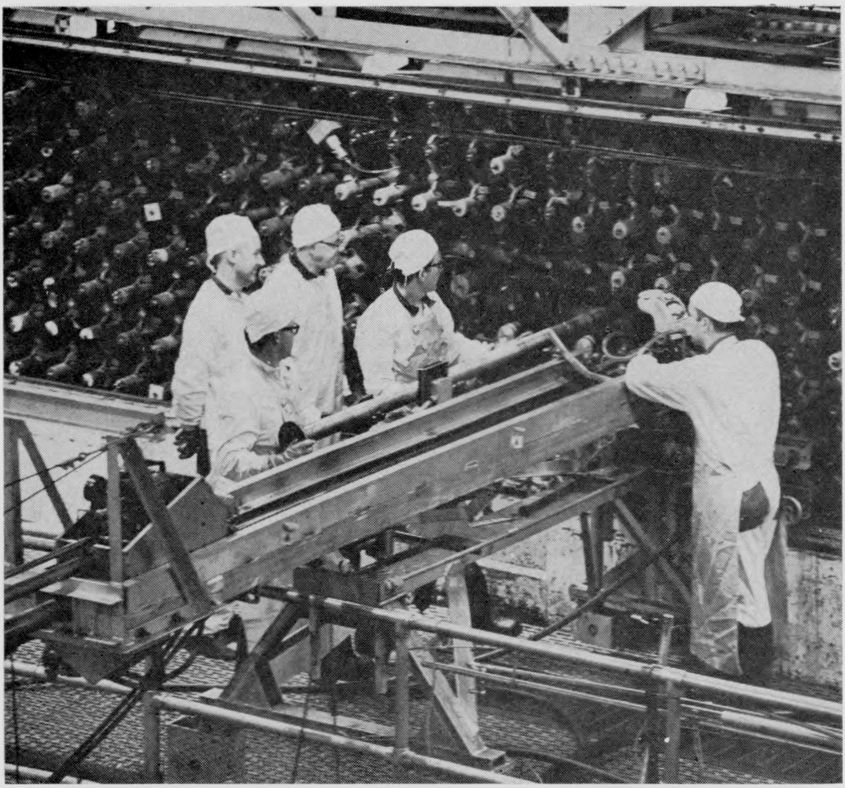
Washington Public Power Supply System. Byproduct steam from "N" reactor operation continued to be supplied to the Washington Public Power Supply System (WPPSS) generating station. Total electrical generation at the WPPSS plant during 1968 was about 4 million megawatt hours as compared to slightly over 2 million megawatt hours in the previous year. Power output during the first half of the year was held below the design output of 800 Mwe. by repair work on the main heat exchangers and because of certain difficulties encountered with experimental fuel elements. However, increased efficiency of operations near the year's end permitted electrical power output to approach that achieved in 1967 during the high-power probe tests—above 4,000 thermal megawatts.

Other Hanford Reactor Operations. The three other operating reactors ("C", "KE", and "KW") at Hanford continued to produce plutonium for weapon and reactor development applications. At midyear, some productive capacity was again used for thorium loadings to complete the production of uranium-233 for the Light Water Breeder Reactor (LWBR) program (see Ch. 5—"Reactor Development and Technology").

In January 1968, 44 process channels in "C" reactor were enlarged and process tubes about one-inch larger in diameter than the original tubes were installed. This test group replaced a block of somewhat smaller diameter channels installed some years ago. Larger diameter rod-in-tube fuel elements fabricated by a new hot-die-size process have been satisfactorily irradiated in this demonstration of "overbore" capability.

Specialty Irradiations. Specialty irradiations were made in the Hanford reactors in support of atomic energy and space programs. Various type nuclear fuel elements and materials were tested for North American Rockwell, NASA-Lewis, United Nuclear Corp., and the Pacific Northwest Laboratory. In addition, specialty isotopes were irradiated for Oak Ridge National Laboratory and NASA-Ames.

Radioactivity Levels Reduced. Late in 1968, the U.S. Geological Survey hydrologists reported that, in 1966, the Columbia River carried 50 percent less radioactive material than it did before 1964 (see also "Operational Safety," Chapter 7). The average daily radioactivity levels—never high enough to constitute a hazard—were reduced as a result of the 1964–66 shutdown of three production reactors at Hanford and improved operating methods for the other reactors. Since the 1966 survey, two additional Hanford reactors have been shut down.



Forty-Four Oversize Process Tubes were installed by Douglas United Nuclear in Hanford's "C" reactor early this year. Into these process tubes were charged a number of fuel elements about 1 inch larger in diameter and significantly heavier than standard "C" reactor fuel elements. These fuel elements are a rod-in-tube design. They were irradiated in "C" reactor to demonstrate the advantages of this design over the smaller "C" reactor fuel element; they provide greater nuclear safety, lower product costs, reduce use of fissionable materials, and a significant increase in the reactors' capability to create radioisotopes other than plutonium-239.

Savannah River Reactors

During 1968, the Savannah River reactors primarily produced plutonium for weapons, peaceful applications, and development programs. In addition, a large number of special assemblies were irradiated. These included cobalt, thorium, neptunium, bismuth, thulium, depleted uranium, lithium, and europium targets. A major new development during the year was initiation of the production of plutonium-239 using enriched uranium fuel and depleted uranium targets. The purpose of this mode of operation is to obtain high burnup of the uranium-235 in the enriched uranium fuel so as to increase the production of uranium-236 and neptunium-237. The neptunium-237, in turn, is used as target material in producing plutonium-238.

High-flux Operation. A program was approved in 1968 to operate a Savannah River reactor in a high-flux mode to produce significant quantities of californium-252. The first of two successive high-flux irradiation campaigns (each lasting about 1 year) is scheduled to begin the latter part of 1969. Residues (plutonium-242, americium, and curium) from the curium-244 production program completed in 1967 [6] will be used as target material for the high-flux irradiations.

Resonance Reactor. Studies completed in 1967 indicated that conversion of a Savannah River reactor for resonance operation [7] can produce large quantities of californium-252 at the lowest cost. The most desirable reactor conversion would involve displacing 80 to 90 percent of the heavy water moderator with a nuclearly suitable (low-neutron-moderating, low-neutron-absorbing) material, such as magnesium, bismuth, bismuth oxide, or a magnesium alloy.

Specific data are being obtained for candidate materials in tests that approach the resonance conditions of radiation, corrosion, and intermetallic diffusion between the displacer cores and cladding. Special fuel assemblies are being designed for irradiating the materials in the Savannah River reactors, a test loop is being designed for corrosion study, and liaison is maintained with materials irradiation programs in the High Flux Isotope Reactor (HFIR) at Oak Ridge.

Californium–252

The manmade heavy element, californium-252 (Cf^{252}), is an intense neutron emitter, emits gamma radiation at only a low rate, generates insignificant heat, and has a relatively long half-life of 2.65 years.

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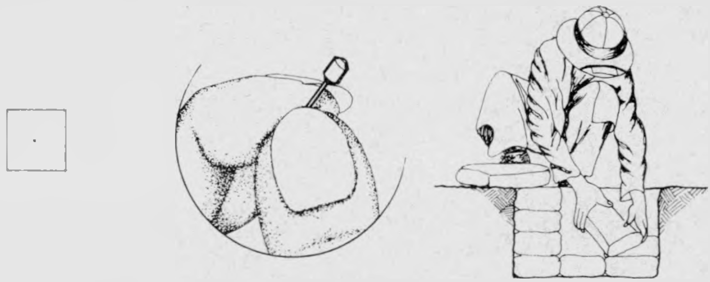
6 See p. 40, "Annual Report to Congress for 1967."
7 See p. 41, "Annual Report to Congress for 1967."

These properties make Cf^{252} a superior source of neutrons in comparison with other radioisotopes which can serve as neutron sources.

The sale price of californium-252 would be $450 billion per pound—if a pound were available. Since Cf^{252} is not available in quantities as large as a pound, the AEC's quoted price for its purchase is the equivalent of the billions per pound figure—$100 for one-tenth of a microgram (one ten-millionth of a gram).

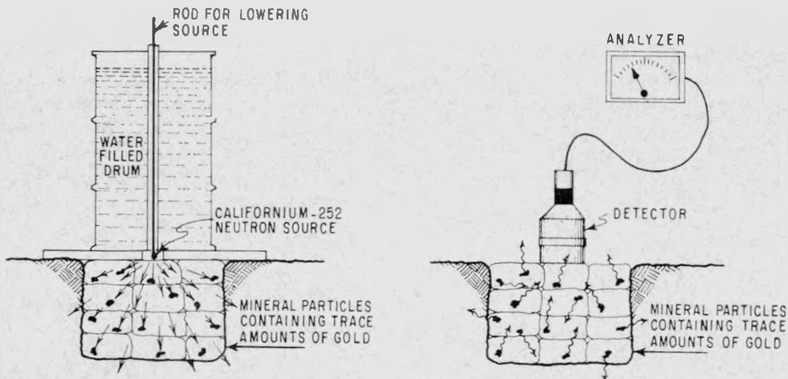
CALIFORNIUM-252 AS USED IN MINERAL EXPLORATION EXPERIMENTS



(1) Amount of californium used was about the size of the dot in the above box.

(2) Platinum foil compacted into a pellet about the size of a pencil eraser holds source.

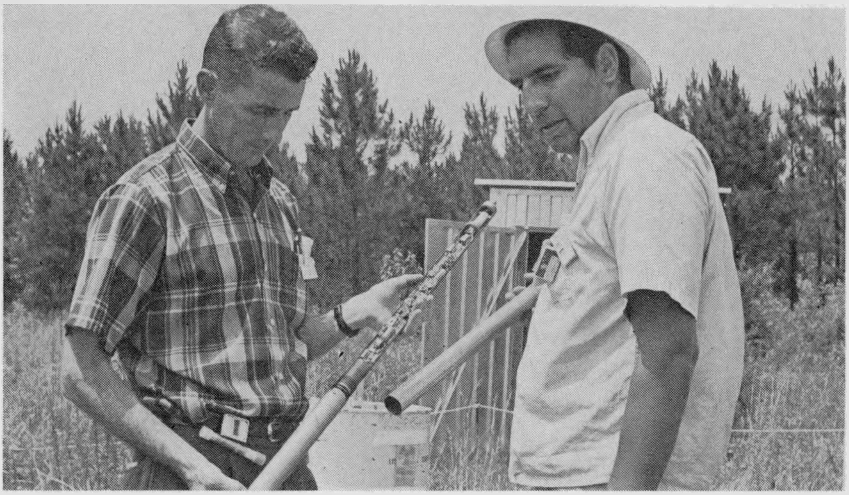
(3) Sacks of low-grade ore from Nevada containing only 1/3 of an ounce of gold* per ton were stacked in shallow hole.



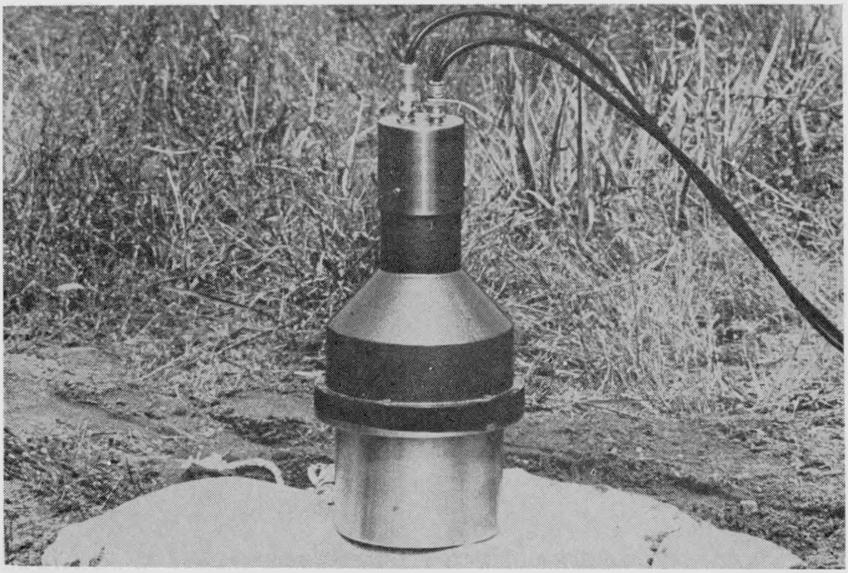
(4) Water filled drum (which shields personnel from neutron radiation) is placed over ore samples. Source rod is then pushed down to bring source in contact with samples. Neutrons emitted by californium atoms strike atoms of gold and are absorbed, making gold atoms radioactive.

(5) Radioactive gold atoms emit gamma rays, some of which strike detector which has been placed over ore samples after removal of californium source. Analyzer then determines amount of gold in ground minerals.

*Although gold is used as an illustration, silver was also detected by this technique, which is applicable to other minerals as well.



Mineral Exploration Using Californium-252 was demonstrated by a technical team from the U.S. Geological Survey at the Savannah River Plant during the year. The overall procedure is shown on *opposite* page. A probe containing only 100 micrograms of Cf^{252} and electronic instruments (shown *above* without the Cf^{252} source) was lowered into a borehole as illustrated in "4" on *opposite* page. Neutrons emitted by spontaneous fission of the Cf^{252} activated the surrounding minerals, inducing secondary radiation that could be detected and recognized as characteristics of particular elements. The detector and an associated amplifier are shown *below*. Samples of ore containing traces of gold and silver were readily detected. Californium is being produced in small quantities in the Savannah River production reactors operating at high flux by successive capture of neutrons in targets containing heavy elements. (See other photos on page 4 of Introductory Chapter.)



Market Development

The AEC, during 1968, undertook the first phase of development of a large-scale market for californium-252. Through its Savannah River Operations Office, the AEC is distributing on loan various types of encapsulated neutron sources for market development studies. About 12 milligrams [8] of Cf^{252} being recovered from the current curium-244 program at Savannah River, supplemented by several milligrams provided from the HFIR at Oak Ridge, are being used for this purpose.

The initial source was small—1.4 micrograms [8] of Cf^{252} in a needle for cancer research.[9] Sources proposed for studies of neutron activation, and mineral exploration will be larger. Sources are also expected to be used in studies of medical and industrial radiography, and petroleum exploration.

Developmental Uses

Some studies on uses of neutron sources already underway include: potential use of Cf^{252} needles for cancer therapy at Brookhaven National Laboratory and the M. D. Anderson Hospital and Tumor Institute, Houston, Tex.; neutron radiography at Argonne National Laboratory, the Savannah River Laboratory, and the Medical College of Georgia; safeguards research at Los Alamos Scientific Laboratory; and activation analysis at Oak Ridge National Laboratory, U.S. Bureau of Mines, and the U.S. Geological Survey (USGS). In a demonstration at Savannah River, the USGS used a one hundred microgram Cf^{252} source in conjunction with equipment to: (*a*) detect low concentrations of gold and silver ore that had been deliberately seeded in the ground; (*b*) detect rare earths in phosphorite samples obtained from the Bone Valley formation near Bartow, Fla.; and (*c*) to make a continuous neutron activation log of a geologic test well down to 1,100 feet.

Large-Scale Production Anticipated

Results obtained from all of these studies will determine the extent to which the AEC will proceed with plans for large-scale production of Cf^{252} in the Savannah River reactors. A concurrent technical development program is planned so as to support requirements and timing, indicated as the market development program progresses, for reactor modifications, target fabrication, chemical separations, and encapsulation.

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

[9] See p. 104, "Annual Report to Congress for 1966."

Heavy Water Production

Production of heavy water at the Savannah River Plant amounted to 206 tons during 1968 which was about equal to production in 1967.

Sales Exceed Production

In May 1968, the sales price of heavy water was increased from $24.50 to $28.50 a pound because of higher operating costs, caused by higher maintenance costs, higher wage and salary rates, and rising steam power costs. Heavy water sales continued to exceed the annual production, thus reducing the AEC inventory of this product. Sales to U.S. customers, primarily for research use and for the manufacture of deuterium gas and deuterated compounds, totaled 8 tons, a 33 percent increase over 1967 sales. Foreign sales totaled 245 tons, a 300 percent increase over sales delivered in 1967.

Projected requirements for the next several years exceed the available supply, and sales will continue to be made on a first-come-first-served basis.

Waste Management

The established practice of evaporation and concentration of "aged" stored radioactive wastes at Hanford and Savannah River is continuing.[10] The advantage gained is reduced volume and lessened mobility of the wastes.

Hanford. At the Hanford B-Plant, cesium-137 and strontium-90 are being removed from stored (aged) radioactive wastes.[11] Removal of these long-lived heat emitters is followed by an extensive evaporation step that converts the waste liquids into less mobile "salt cakes" within the underground waste storage tanks. The separated cesium and strontium are being stored in cooled stainless-steel tanks in B-Plant cells until facilities are provided to solidify and encapsulate them in high integrity containers.

Strontium is also being removed in the B-Plant from fresh wastes from the Hanford Purex chemical processing plant and equipment is being installed to remove cesium from these wastes. The remaining wastes then will be converted into "salt cakes" after a suitable period to allow for decay of the shorter-lived heat-generating nuclides.

Savannah River. At the Savannah River Plant, an investigation is being made of the feasibility of storing radioactive wastes from the

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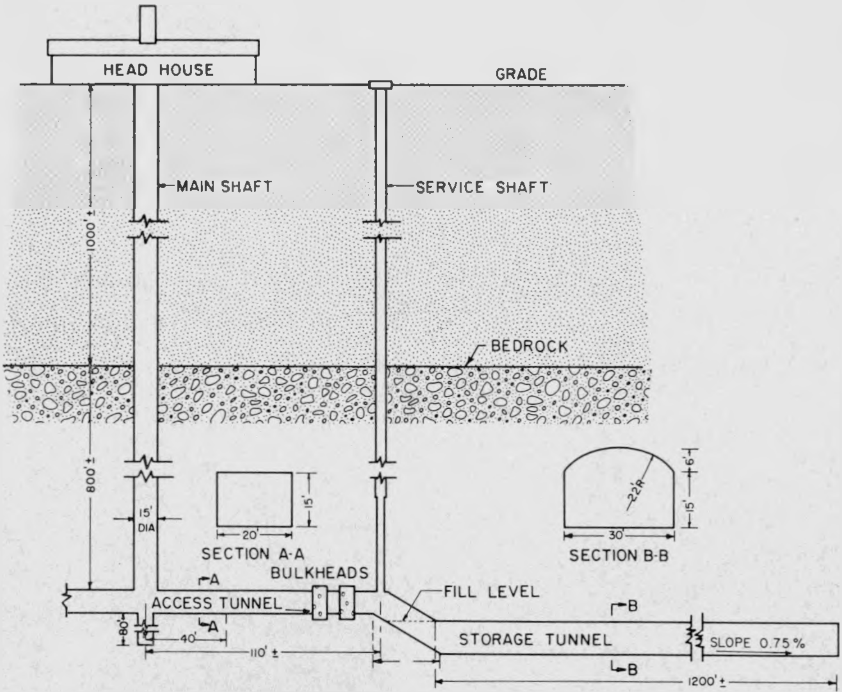
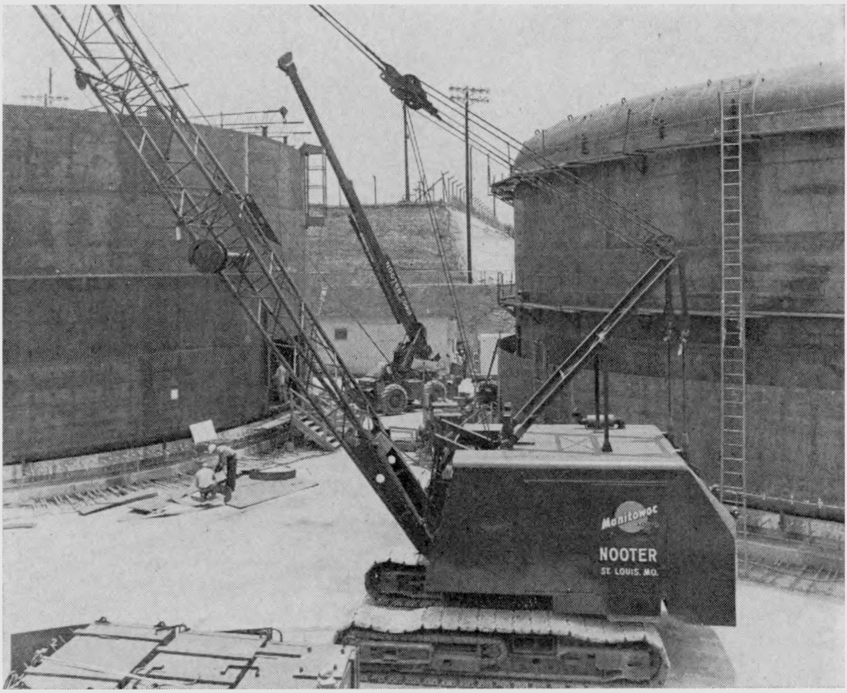
[10] See p. 112, "Annual Report to Congress for 1966."
[11] See p. 46, "Annual Report to Congress for 1967."

chemical separations plants in unlined tunnels excavated in crystalline bedrock 1,500-2,000 feet beneath the earth's surface at the plant. In the meantime, the stored wastes are being concentrated to the point that solids are crystallizing in tanks. The crystallized wastes represent a safer form for interim tank storage and they can be redissolved at a future date when the wastes are to be treated or transferred to a suitable location for long-term storage.



The Feasibility of Storing Radioactive Wastes in unlined tunnels excavated in crystalline bedrock 1,500–2,000 feet beneath the earth's surface is under study at the Savannah River Plant. Drawing *above* shows the concept. Meanwhile, stored wastes are being crystallized in holding tanks. Photo at *left*, taken by a periscope camera, shows encrustations of salt that have crystallized from the concentrated waste solutions. The crystallized wastes are a safer form for interim tank storage pending transfer to a suitable location for long-term storage.

Idaho. At the National Reactor Testing Station in Idaho, the Waste Calciner Facility (WCF) operated with a feed of zirconium-type waste until March when the facility was shut down for maintenance. The highly corrosive action of the fluoride ion in the zirconium waste is neutralized by adding calcium nitrate to the WCF feed. Operation resumed in August on zirconium waste feed and continued through the year. By the end of 1968, the WCF had converted 300,000 gallons of zirconium-type liquid waste to 27,000 gallons of the granular calcine [12] stored in bins in underground vaults.



Four 1.3-Million-Gallon Tanks are being constructed at the Savannah River Plant for the storage of radioactive wastes. Two of the four, shown in the photo, are nearing the completion of their double steel shells. Shortly after this stage of fabrication the inner tanks are stress relieved—the largest carbon steel vessels of this design to be so treated. To do this, hot exhaust gases from heaters located on a tank top are directed into its interior. The interior wall temperature is gradually raised, and then held at 1,100° F. for 1 hour. At that temperature, a tank's 85-foot diameter has increased by 9 inches; to prevent sagging, the tank top is independently supported by temporary trusses, visible at the *upper left*. The heat treatment removes welding stresses that make the steel susceptible to cracking when exposed to the concentrated sodium nitrate—sodium hydroxide of the waste solution.

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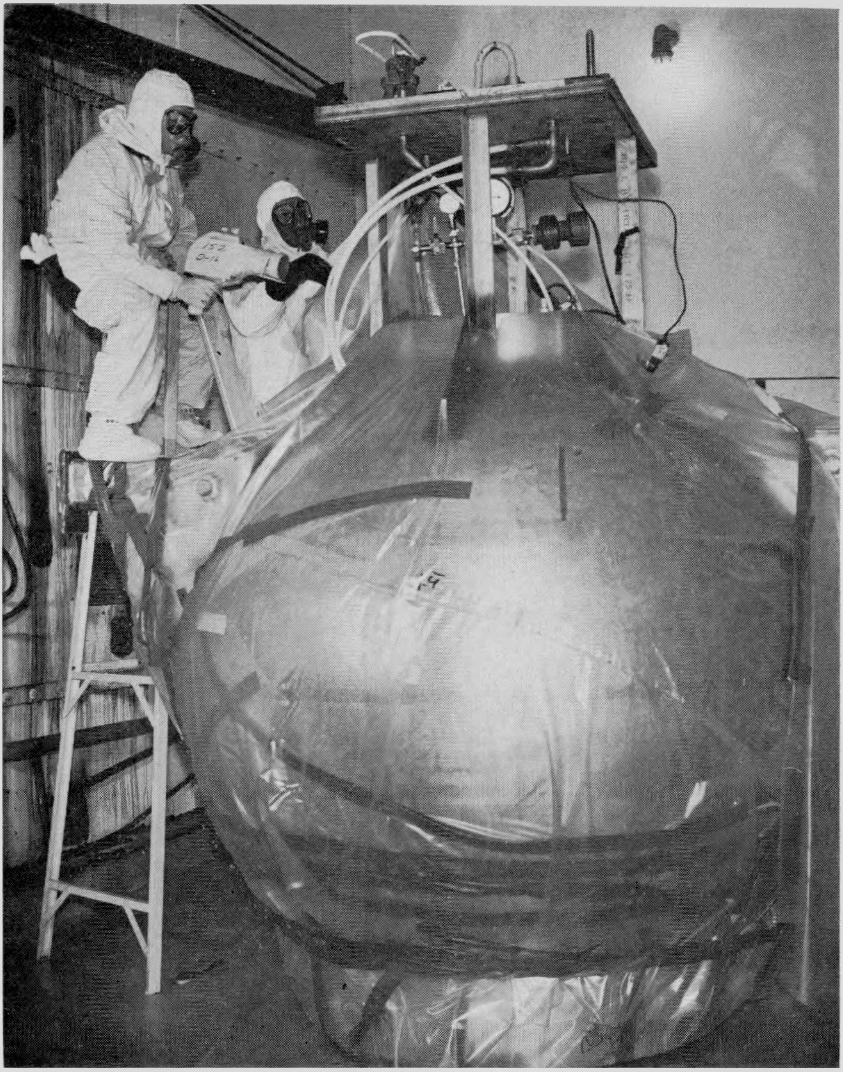
[12] See p. 6, "Annual Report to Congress for 1967."



Largest Amount of Curium-244 ever recovered was contained in this 30-ton plastic-draped "bowling ball" cask; the purification of the material was completed early this year at the Hanford plant. The curium was recovered along with americium from the wastes of Shippingport power reactor fuels that had been processed in the Redox chemical separations plant before the plant entered standby status (see also Chapter 17, "Administrative and Management Matters"). The Shippingport fuel curium is an excellent source of heat for certain aerospace or difficult-to-maintain remote applications. New technology developed by the Pacific Northwest Laboratory made possible this first recovery of curium or americium from a material representative of power reactor fuels. Atlantic Richfield Hanford Co. (ARHCO) operates the chemical processing facilities at Hanford for the AEC.

Fission Products

Crude fractions of fission-product cerium, promethium, strontium, and cesium were separated from radioactive wastes at the Hanford chemical separations facilities. Some 17,570,000 curies of cerium-144, 12,300,000 curies of promethium-147, and 60,000 curies of strontium-90 were transferred to Pacific Northwest Laboratory. In addition, 100,000 curies of cesium-137 were shipped to Oak Ridge National Laboratory.

The AEC announced on October 31 that its Richland Operations Office would seek expressions of interest in the recovery of fission product rhodium, palladium, and technetium from Hanford wastes.[13] By year's end, nine companies had notified the AEC of their intention to respond to the invitation. They were: Isotopes, Inc., Atlantic Richfield; Westinghouse; National Lead; Engelhardt Industries; Union Carbide; Cleveland Refractory Metals; Research Chemicals Div. of Chemical Separations Corp.; and Universal Oil Products.

RADIOISOTOPE SALES

During the 11 months ending November 30, 1968, 3,380,146 curies of processed radioisotopes were distributed by Oak Ridge National Laboratory. The AEC's radioisotope sales were up 8.7 percent from the same period in 1967. The Isotopes Development Center at Oak Ridge National Laboratory (ORNL) serves as the primary sales point for AEC-produced radioisotopes. When a specific radioisotope becomes available in quantity and at reasonable cost from commercial producers, the AEC withdraws from the routine production and distribution of that isotope.

Sales Withdrawals

The mid-March action ending the production and sale of cobalt-60 sources of 45 curies per gram specific activity and less completed the AEC's withdrawal from the routine sale of this isotope. (Sale of higher specific activity cobalt-60 sources had been discontinued previously.) Since 1961, the AEC has withdrawn from the production and sale of 37 isotopes as commercial sources demonstrated the capability to supply the market on a competitive basis.

The withdrawals are in keeping with the AEC policy of fostering commercial radioisotope production and distribution. The practical

[13] See pp. 47–49, "Annual Report to Congress for 1967."

consequence of this policy, which has been in effect since 1965, is reflected in the present participation of at least six privately owned nuclear reactors in production of radioisotopes and the additional participation of about 100 commercial radioisotope processors and distributors. Since 1961, the AEC has withdrawn from sale of:

Antimony-124
Antimony-125
Arsenic-76
Arsenic-77
Bromine-82
Cadmium-109
Cadmium-115
Cadmium-115^m
Calcium-45
Cerium-141
Cesium-134
Chromium-51
Cobalt-58
Cobalt-60 (metallic sources)
Copper-64
Gold-198
Gold-199
Iodine-125
Iodine-131
Iridium-192 (metallic sources)
Iron-55
Iron-59
Lanthanum-140
Mercury-197
Mercury-203
Molybdenum-99
Molybdenum-99-technetium-99^m generator
Phosphorus-32
Potassium-42
Selenium-75
Silver-110
Sodium-24
Strontium-85
Strontium-87^m
Sulfur-35
Tin-113
Zinc-65

Price Changes

During 1968, the AEC reduced its price[14] for tritium, polonium-210, neptunium-237, americium-241, and batch sales of 10 or more grams of iodine-129. The AEC also announced its intention to continue the present prices of strontium-90 and promethium-147 in view of substantial private investments in research, development and applications of these isotopes. The AEC will reexamine strontium-90 and promethium-147 prices in a year or two in relation to full cost recovery, growth of market demand, extent of private research, development, and applications investment, and the possibilities for private separation and marketing of these materials. The AEC also published in the *Federal Register* of June 6, 1968, for public comment, a notice of proposed price increases for cesium-137; at year's end, the new cesium-137 prices had not been determined.

The AEC established a schedule of charges for plutonium to cover a wide range of isotopic assays useful in research and development programs. These charges are related to the costs of producing plutonium in AEC facilities and, depending on the assay, vary from $42 to $70 per gram of the isotopes plutonium-239 plus plutonium-241 in plutonium nitrate form. In addition to AEC facilities, civilian power reactors owned by electric utilities produce plutonium which is available for use by licensees without any necessary financial involvement by the AEC.

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[14] A full list of prices is available from the Isotopes Sales Dept., Isotopes Development Center, Oak Ridge National Laboratory, Post Office Box X, Oak Ridge, Tenn. 37830.

New Products

As industry has assumed increasing responsibility for routine production of many isotopes, research work at AEC radioisotope production sites has been concentrated more on the development of methods for producing new isotope preparations having importance in many fields of research. During the year, phosphorus-33 and experimental quantities of enriched krypton-85 were made available from ORNL.

The routine availability of phosphorus-33 provides the opportunity for research investigators to take advantage of at least two desirable features that make it particularly useful in many ecological and agricultural studies as well as in biomedical research. It has a longer half-life than phosphorus-32 (25 days as compared to 14.3 days) thereby extending the duration of experiments; and its lower radiation energy results in a much lower radiation dose to the system under study.

Approximately 2,000 curies of krypton-85 were enriched to a range of 10–27 percent purity by thermal diffusion at Oak Ridge National Laboratory. Since normal krypton produced during the fission process contains only about 5 percent krypton-85, the enrichment is expected to increase its use in luminescent, secondary X-ray, and beta radiation applications. Experimental quantities of this product have been purchased by industry and a pilot production study is continuing to obtain higher enrichments and to study operational problems.

Chapter 2

NUCLEAR MATERIALS SAFEGUARDS

MAINTAINING SAFEGUARDS

During 1968, the AEC continued to improve its program for safeguarding special nuclear material from the standpoint of the common defense and security to maintain its effectiveness in the environment of the rapidly expanding nuclear power industry.

From the beginning of the United States atomic energy program, the distribution and use of nuclear materials have been carefully controlled and safeguarded. However, it became evident that there was a need to expand and modify the procedures for safeguarding nuclear materials against diversions to unauthorized uses when, in 1966, the use of nuclear energy for production of electricity began its current rapid expansion. Accordingly, the AEC initiated its broadened safeguards program.[1] The AEC's safeguards program has a direct association with the International Atomic Energy Agency's (IAEA) safeguards efforts, in accordance with the U.S. proposal, the IAEA is the logical international body to monitor nuclear matters under the provisions of the treaty on Non-Proliferation of Nuclear Weapons which was signed during 1968 (see "AEC Programs and the Non-Proliferation Treaty" item in Introductory chapter).

The Need for Safeguards

Three nuclear materials—uranium-233, uranium-235, and plutonium—can be used to create and sustain a fission chain reaction. Only uranium-235 (U^{235}) exists in nature, the other two are created artificially. At least one of these three primary fissionable materials is needed in the fuel for a nuclear power reactor. After use in a power reactor, the "spent" fuel elements can be reprocessed to recover the

[1] See pp. 51–55, "Annual Report to Congress for 1967."

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remaining "unburned" uranium and the plutonium that has been created.

Thus, power reactors can create two of the three nuclear materials—uranium-233 (U^{233}), and plutonium—which could be used for nuclear weapons; enriched uranium-235 is the third material. Countries not now possessing nuclear weapons but having a present or future capability for nuclear power generation have a potential source of the nuclear materials which could be used for a weapons program.

1968 ACTIVITIES

In the first full year of operation under the reorganized safeguards program announced in 1967, substantial progress was made in upgrading safeguards procedures applicable to licensees. In developing safeguards policy for the future, the AEC has analyzed its program in the light of projected nuclear industry growth and international aspects. As a result, its safeguards research and development program is being aimed at developing the capability to provide independent and credible assurance that the safeguards are effective in the expanding industry environment, primarily through the use of instrumentation.

Regulatory Actions

Material Controls and Inspections

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 U^{235}, U^{233}, and/or plutonium in an unsealed form. At the end of 1968, there were 27 facilities operated by such licensees, including nuclear fuel processors, fabricators, and reprocessors. In addition, the growing number of licensed power reactors are subject to AEC safeguards inspections.

Salient regulatory actions to implement the domestic safeguards program during 1968 included the following:

- All affected licensees submitted to the AEC a description of their material control and accounting procedures for safeguarding special nuclear material, in conformance with a guide [2] which was prepared and disseminated during the year.

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[2] The AEC "Guide for Preparation of Fundamental Material Controls and Nuclear Materials Safeguards Procedures" is available from the Division of Nuclear Materials Safeguards, Office of Director of Regulation, U.S. Atomic Energy Commission, Washington, D.C. 20545.

- The AEC reviewed the proposed safeguards programs of licensees and began to amend their licenses to incorporate the appropriate material controls as license conditions.
- By the end of 1968, three new District Safeguards Offices[3] had conducted 24 inspections of licensed facilities to determine compliance with safeguards license conditions.

Reporting Requirements Extended

The AEC's regulations were amended in July (*Federal Register* of June 27, 1968) to extend to privately owned material the reporting requirements applicable to Government-owned special nuclear material so that these requirements are applicable to all such material regardless of its origin. Agreement State[4] licensees are also required to submit to the AEC reports of transfers and receipts of special nuclear material. Previously, such reports were required by the regulations only from AEC licensees. The AEC exempted licensees authorized to possess 350 grams or less of contained U^{235}, U^{233}, and/or plutonium from certain safeguards requirements, including periodic reporting, and also has exempted all licensees from having to report transfers of special nuclear material containing less than one gram of U^{235}, U^{233}, or plutonium.

Programmatic Activities

Support Unit Established

The AEC established a Technical Support Organization at Brookhaven National Laboratory to perform technical planning and review the safeguards research and development performed by others for the AEC. The group will analyze data from systems studies of fuel and material conversion and fabrication cycles. These systems are being performed as a part of the safeguards research and development program.

AEC-DOD Committee

The AEC and the Department of Defense (DOD) established an *ad hoc* advisory committee composed of six senior representatives

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[3] The District I Office is located in Newark, N.J.; District II in Oak Ridge, Tenn.; and District III in Berkeley, Calif.

[4] States to which the AEC has transferred regulatory authority over byproduct, source, and small amounts of special nuclear materials under sec. 274 of the Atomic Energy Act of 1954, as amended (see "State Regulatory Agreements" section in Ch. 6—"Licensing and Regulating the Atom").

from the DOD including members from each of the military services and five senior members representing the AEC. The committee was assigned the mission of reviewing the safeguards applicable to materials and weapons transferred to Defense, with particular emphasis on the safeguards applied during transportation phases. The committee is expected to report its findings and recommendations for strengthening safeguards early in 1969.

Safeguards Training School

The AEC established a Safeguards Training School at Argonne National Laboratory for the training of AEC inspectors, international safeguard inspectors, and atomic energy industry employees in nuclear materials management and safeguards. The first class met during the fall of 1968. Its 16 members included five foreign participants, two representatives from industry, five representatives from AEC contractors and four AEC employees. The size of the class was kept small to facilitate training. Instruction covered items in the nuclear fuel cycle, analytical methods, records systems, and audit procedures. Plans for the next class are under consideration.

International Safeguards Activities

IAEA Safeguards

The AEC participated in multilateral safeguards panels conducted by the International Atomic Energy Agency (IAEA) in Vienna. The first one in April was concerned with safeguards on chemical processing plants and the second one in September dealt with reactor safeguards. Meetings between U.S. and IAEA safeguards personnel were also held in Washington in May and November dealing with a wide range of safeguards related matters.

After several meetings in Vienna in which the United States participated, the IAEA in June 1968 supplemented its safeguards procedures document to extend IAEA safeguards to nuclear material conversion and fabrication.

During 1968, increasing emphasis was placed in discussions with IAEA, Euratom, and some IAEA member nations on safeguards research and development. The objective is to achieve full coordination, avoid unnecessary duplication, and identify areas for joint projects.

International Safeguards Inspection

The AEC conducted bilateral safeguards inspections of 57 facilities in 10 foreign countries during 1968. IAEA safeguards inspections in the United States under the 1962 Four-Reactor Agreement [5] were carried out 7 times, including one unannounced inspection at Yankee. Of the four reactors (Yankee Nuclear Power Station, Brookhaven Graphite Research Reactor, Brookhaven Medical Research Reactor, and Piqua Organic Moderated Reactor), the Brookhaven Graphite Reactor was placed on standby status and Piqua was shut down and its fuel removed. Nevertheless, all four reactors will continue to be subject to the appropriate IAEA safeguards for the duration of the agreement. Under a special safeguards arrangement, personnel from the Canadian Atomic Energy Control Board inspected Canadian natural uranium being processed in the United States prior to eventual use in power reactors abroad.

Euratom Safeguards

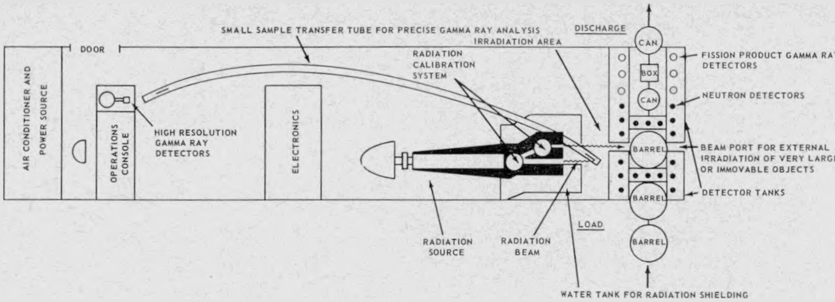
The AEC continued its close liaison with European Atomic Energy Community (Euratom) safeguards officials, through liaison conducted by the U.S. Mission to the European Communities in Brussels, through visits and communications by senior AEC Headquarters personnel, and through contacts related to the Joint Technical Working Group. Meetings of subgroups of the Joint Technical Working Group were held in January in Washington, and in Brussels and Vienna in September. In April, a visit was made to the Eurochemic fuel reprocessing plant at Mol, Belgium, at which Euratom resident inspection is applied.

Research and Development

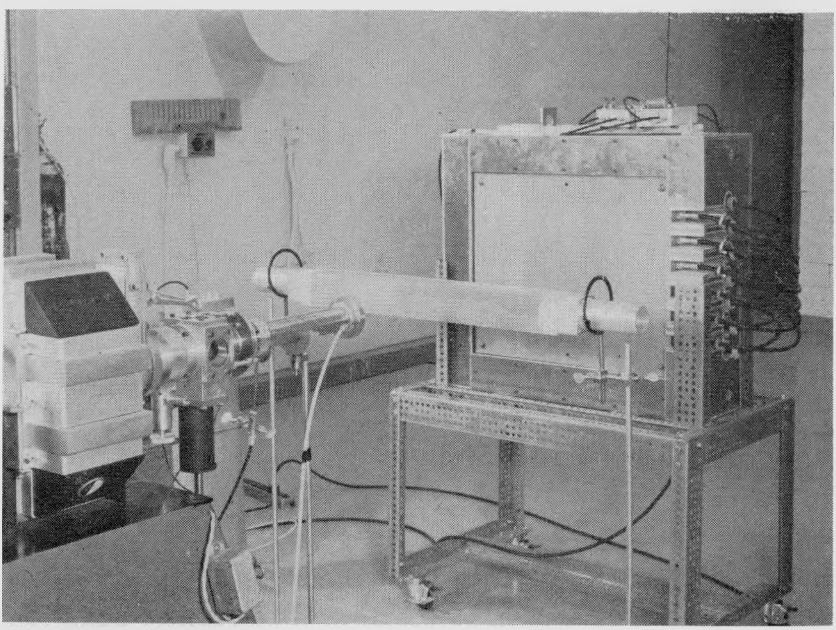
Safeguards Research Objective

One primary objective of the AEC's safeguards research and development program is to develop more accurate instruments and techniques for measuring the quantity of various fissionable isotopes in nuclear materials whether during fabrication processes, included as scrap, or contained in "spent" (used) reactor fuel assemblies. Another primary objective is concerned with development of methods and

[5] In 1960, the United States offered to make four reactor facilities open to IAEA inspectors as a means of lending support to the agency safeguards program and to further its development by providing, in effect, a field laboratory for IAEA inspection personnel. The IAEA Board of Governors approved such an agreement in 1962.



A Complete Nondestructive Nuclear material assay station as might be mounted in a semitruck trailer is shown in the schematic layout *above*. Such transportable systems, under development by Gulf General Atomic, San Diego, Calif., and Los Alamos Scientific Laboratory, could be moved into a fuel storage area or located contiguous to a normal fuel handling or processing operation. Photo *below* shows the experimental arrangement for nondestructive isotopic assay of a nuclear reactor fuel element. This Los Alamos Scientific Laboratory setup features a unique "slab" neutron detector specially designed for delayed neutron measurements. The neutrons emerge from the small accelerator (at *left*), pass through the fuel element (*center*), and impact in detector (on *right*). The neutron source can be "spectrum tailored" for specific isotopes or test sample configurations.



procedures for preventing, as well as detecting, the diversion of nuclear material to unauthorized uses. These methods are expected to include physical protection as well as accountability which will provide a validation of inventory records of the large stockpile of nuclear fuel material used in power reactors or handled in fuel fabrication and reprocessing plants. By enabling more accurate accountability of these materials, the methods will provide a check against clandestine diversions of these strategic materials to nonpeaceful uses as well as helping industry to protect its economic investment in these expensive materials.

Program Details

A special section of the AEC's "Fundamental Nuclear Energy Research—1968" report,[6] which supplements this "Annual Report to Congress," summarizes the basic research being done under the safeguards research and development program. This work includes research projects to develop nondestructive assay techniques for uranium and plutonium. The summary includes information on:

- The unique "energy dependence" of delayed neutron yields from different fissioning isotopes can be of practical significance in the development of assay techniques based on measured delayed neutron yields per fission.
- Special radiation sources are in use which can be "spectrum-tailored" for the particular isotope or geometric configuration of interest.
- Conceptual designs of both transportable and stationary assay stations are being developed. The nondestructive assay stations will make quantitative isotopic measurements of special nuclear materials in bulk heterogeneous mixtures such as assembled nuclear reactor fuel elements, various types of process containers, and barrels of scrap materials. (The drawing and photo on preceding page show two concepts.)

System Studies

Another important part of the AEC's safeguards research program is system studies aimed at improving and best implementing the safeguards nuclear materials control system. Two such studies—evaluation of resident inspection and inventory verification procedures—were conducted during the year.

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[6] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $4.25.

A resident inspection test program was carried out at four commercial nuclear fuel material plants—United Nuclear Corp., Hematite, Mo.; Nuclear Fuel Services, Inc., Erwin, Tenn.; Nuclear Materials & Equipment Corp. (NUMEC), Apollo, Pa.; and NUMEC, Leechburg, Pa.—and at the United States' only commercial spent fuel processing plant—Nuclear Fuel Services, Inc., West Valley, N.Y. Single inspectors were placed in residence at the fuel material plants, and a ten-man inspection team already in residence at the spent fuel processing plant undertook the safeguards resident inspection program. From the detailed data and experience gained in the test program both a quantitative and qualitative evaluation of the effectiveness of resident inspection is being accomplished.

The inventory verification procedures study, made by Pacific Northwest Laboratory, was designed to provide a handbook for inspectors which would: (*a*) standardize the procedures used by AEC inspection teams in verifying nuclear material inventory holdings, and (*b*) provide the statistical basis and procedures for verifying the total amounts of nuclear material in inventory from a fractional sample of the inventory. The ultimate objective of the study was to provide a sound basis for certification statements concerning the total amounts of nuclear material on inventory.

Chapter 3

THE NUCLEAR DEFENSE EFFORT

NUCLEAR WEAPONS

In coordination with the Department of Defense (DOD) which establishes nuclear weapons requirements, the AEC conducts the required basic and applied research for nuclear weapons and devices, develops and tests devices, nuclear weapons and their components (both nuclear and nonnuclear), and produces the DOD-required weapons essential to the maintenance and advancement of the United States nuclear capability.

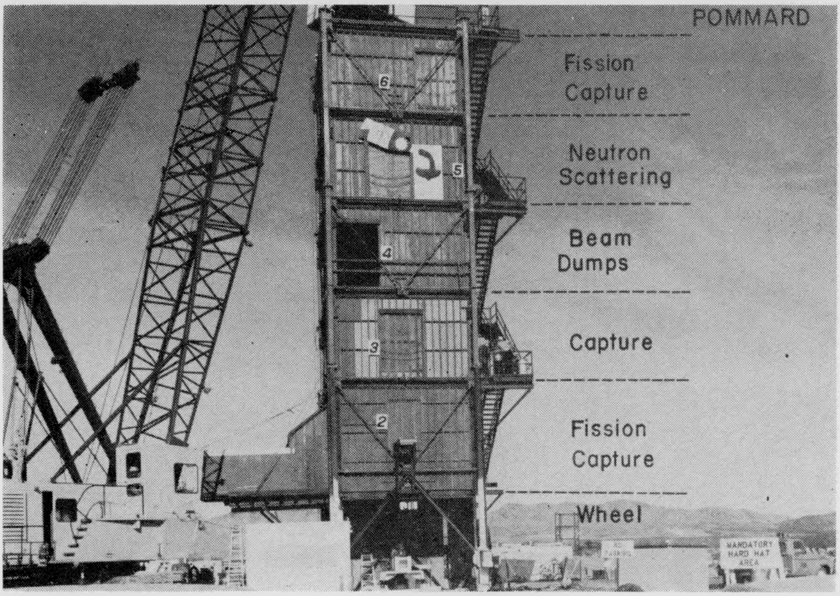
The AEC, during 1968, continued: (*a*) development, testing, and production of nuclear weapons and their components designed to meet stated DOD requirements as approved by the President; (*b*) design and development of nuclear devices, advanced data acquisition systems and diagnostic instrumentation for underground testing; (*c*) maintenance of readiness to resume atmospheric testing, if necessary, as required by the limited nuclear test ban treaty safeguards;[1] (*d*) participation in the DOD-sponsored nuclear detonation detection (Vela) research and development program; and (*e*) cooperation with other countries in Mutual Defense Agreements (including NATO) for the exchange of specified weapon information.[2]

WEAPONS DEVELOPMENT

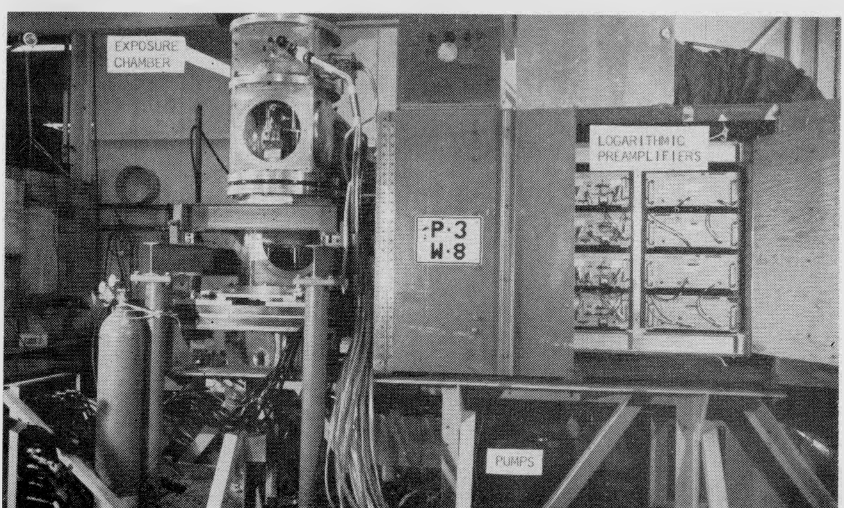
Research and development is essential to meet the specific weapons requirements of the DOD, for advances in weapons technology, and to maintain the viability of the laboratories under the limited nuclear test

[1] The four safeguards, affirmed in 1963 by President Kennedy and reaffirmed in 1964 by President Johnson, as U.S. national policy are: (1) continuation of an aggressive underground nuclear weapons test program; (2) maintenance of a progressive laboratory program; (3) a readiness capability to resume atmospheric tests if they should be essential to national security or if the treaty should be abrogated; and (4) the improvement of our capability, within feasible and practical limits, to monitor the terms of the treaty and to detect violations.

[2] Twelve Mutual Defense Agreements for Cooperation are currently in effect (see app. 6).



A 70-Foot-High Tower, outlined *above* to show the array of scientific experiments performed, topped the emplacement hole for the Los Alamos Scientific Laboratory-conducted, low-yield Pommard weapons test event, March 14, 1968, at the Nevada Test Site. The sled carrying a spinning wheel for radiochemical experiments is shown at ground level. Five separately collimated neutron beams were provided by the detonation some 656 feet below the ground's surface. Photo *below* shows the sled that carried targets for the fission and capture experiments mounted on the second floor of the Pommard tower. The sled was winched down a ramp to a safe area before ground subsidence occurred. These "add on" experiments to underground weapons tests make possible measurements of cross sections on nuclear species that decay so fast that experiments using conventional laboratory neutron sources are impossible.



ban treaty safeguards. The weapons research and development activities are conducted primarily by the AEC's three weapon laboratories (the two nuclear laboratories—Los Alamos Scientific Laboratory, Los Alamos, N. Mex., and the Lawrence Radiation Laboratory, Livermore, Calif.; and the nonnuclear Sandia Laboratories at Albuquerque, N. Mex., and Livermore, Calif.).

The laboratories continued to develop advanced experimental techniques for use in underground testing. These efforts continually and substantially increase the effectiveness of underground testing as a vital means of verifying weapon concepts and designs, of determining weapon and device outputs and effects, and of assuring weapon safety and quality—all essential to the timely meeting of stated military needs. Effort in the development of both weapons and systems was directed toward the exploitation of technological advances, the use of new materials and processes, and new fabrication techniques.

Weapon development tests continued in the underground test program at the Nevada Test Site. The tests combined specific items to meet the stated military requirements with other more complex, highly instrumented "add-on" experiments to provide new information useful to basic science. In addition to the laboratory-sponsored tests, effort was expended in collaboration with, and in support of, DOD-sponsored tests for specific effects.

The continuing facility improvement program, additions to and maintenance of vital scientific computer complexes, challenging research and development programs in all phases of nuclear technology, and the continuing, aggressive underground test program have enabled the laboratories to retain and recruit the necessary technical staff to conduct the assigned programs.

WEAPONS PRODUCTION

The 1968 weapons production effort in support of military requirements was directed primarily toward enhancement of weapon systems capability.

Stockpile Improvement

In addition to the production of new weapons, activities included modification of existing weapons, quality assurance and new materials system testing, providing training weapons and major subassemblies, and retirement and disposal of obsolete weapons.

Emphasis continues to be placed on meeting production objectives at minimum cost, beginning with design and development of weapons and components. Cost considerations permeate the planning and execution of the weapons production program. Special attention was given to usage for training and maintenance purposes of excess and obsolete special-design weapons material.

Production Facilities Expansion

A request was made in late 1968 to provide $315 million for construction and equipment of additional production facilities for new weapons systems desired by the Department of Defense. The $315 million includes $285 million previously authorized. This modernization and expansion is planned to be completed by late 1971.[3] Involved in the basic decisions were the replacement of the current submarine-launched missiles with more modern weapons and deployment of an antiballistic missile system. 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.); Kansas City (Mo.) plant; Mound Laboratory (Ohio); and the Burlington (Iowa) AEC plant.

UNDERGROUND NUCLEAR TESTS

During 1968, a comprehensive underground nuclear test program continued at the Nevada Test Site (NTS). Efforts were made to provide the capability to test higher yields through the development of the Pahute Mesa area at the NTS and the supplemental test areas in Central Nevada and on Amchitka Island in the Aleutian Island chain.

Underground testing received increased public attention in 1968 because of three test events (one of slightly less than 1 megaton yield and two of about 1 megaton yield) fired at Pahute Mesa at the NTS and at the Central Nevada supplemental test area. Following the Faultless event on January 19 and again following Boxcar on April 26, some seismic signals which were apparently related to the tests were received. These signals resulted from motions which occurred intermittently for several weeks after the tests. The strongest of these motions was more than ten times smaller than the motion from the preceding nuclear event and did not constitute any possible safety hazard. All of these motions had epicentral locations within a few miles of the nuclear event epicenter. Preliminary results indicate a similar seismic pattern after Benham on December 19. The investiga-

[3] See p. 60, "Annual Report to Congress for 1967."

tion of aftershocks will continue in order to better define the phenomena. From these studies a better understanding of the generation of earthquakes may be gained, thus enhancing the development of possible models for earthquake prediction.

Initial ground motions from these 3 events were felt at various locations such as Las Vegas, Tonopah, and Salt Lake City. At Hoover Dam, southwest of Las Vegas, the maximum accelerations from the tests have been less than 1/100th of those measured in 1963 during the largest natural earthquake yet recorded at the dam. No test-caused damage to Hoover Dam, or to any other offsite structure, has been discovered.

As a result of the research activities by the laboratories which support the test effort, the AEC has acquired the technology which permits the conduct of some nuclear tests not previously considered feasible in an underground test program.

Crosstie-Bowline Test Series

The 1968 test series includes parts of two series which are conducted on a fiscal year basis. The Crosstie series ended on June 30, 1968. The Bowline series began on July 1, 1968, and runs through June 30, 1969. The planned tests are grouped in three broad categories, (*a*) weapons-related (including device development and DOD nuclear effects tests); (*b*) joint AEC–DOD tests designed for research and development on the improvement of detection methods and systems (Vela Uniform program), and (*c*) Plowshare (peaceful uses of nuclear explosives) experiments (see Ch. 11—"The Plowshare Program"). Planned nuclear tests are reviewed in consonance with AEC-developed procedures for public safety and only carried out with the expectation that they can be conducted within the constraints of the limited nuclear test ban treaty.

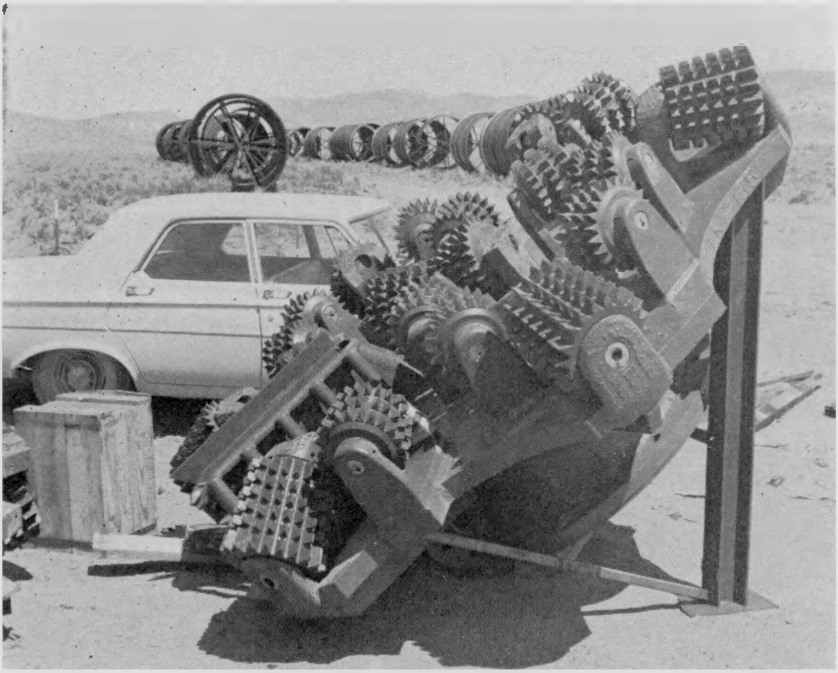
Test Event Summary

Sixteen defense-related underground tests, including two DOD effects tests, were publicly announced in 1968 under the Crosstie series (ending June 30, 1968). Thirteen defense-related tests, including three DOD effects tests, have been publicly announced under the Bowline series (which began July 1, 1968). One of the 29 announced tests was conducted in central Nevada. Seven of the 28 tests conducted at the NTS were in the Pahute Mesa area. (See app. 4 for names, dates, and yield category of defense-related tests announced in 1968.)

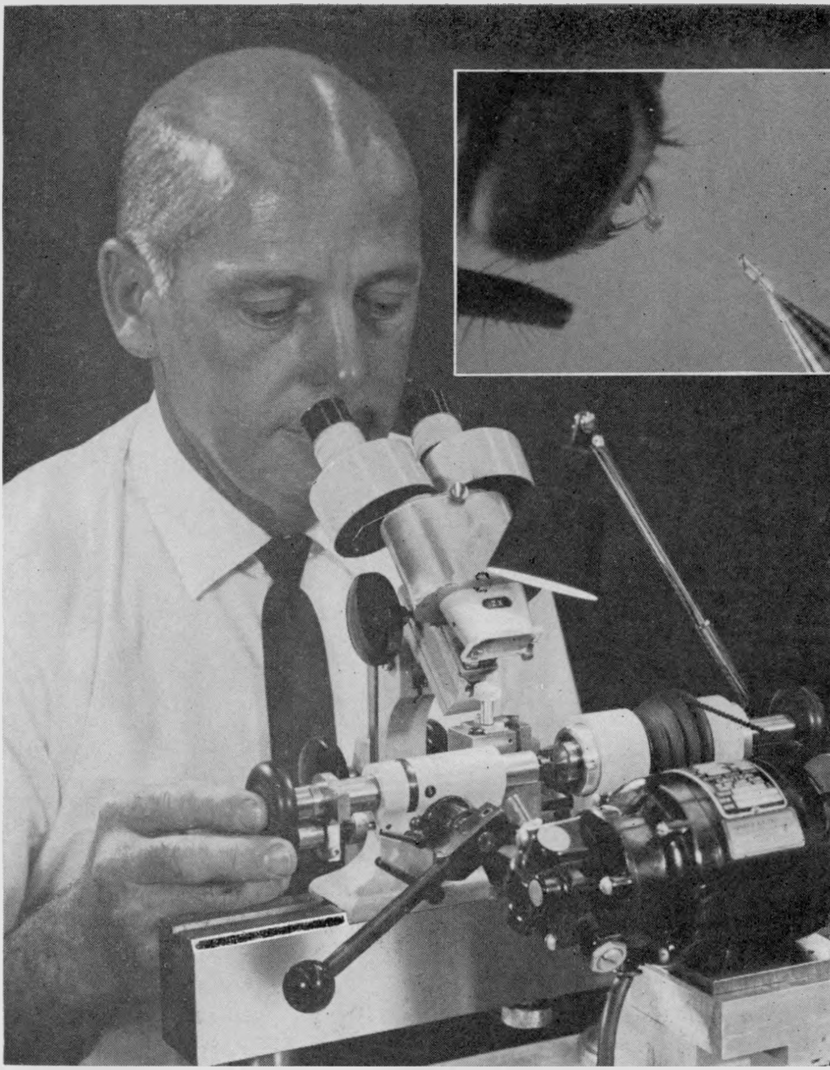
Supplemental Test Areas [4]

Central Nevada. On January 19, 1968, the Faultless test was conducted in the Hot Creek Valley area of central Nevada. The detonation was in the intermediate yield range (200 kt. to 1 Mt.). The purpose of the test was to acquire information on seismic effects and to explore the area as a possible location for other detonations. An austere base camp, roads, airstrip, and technical facilities are under construction at the central Nevada area with a completion date by mid-1969. Two emplacement holes are currently being drilled, with a third to be started in the spring of 1969.

[4] See p. 126, "Annual Report to Congress for 1966" and pp. 60, 61, and 62, "Annual Report to Congress for 1967."

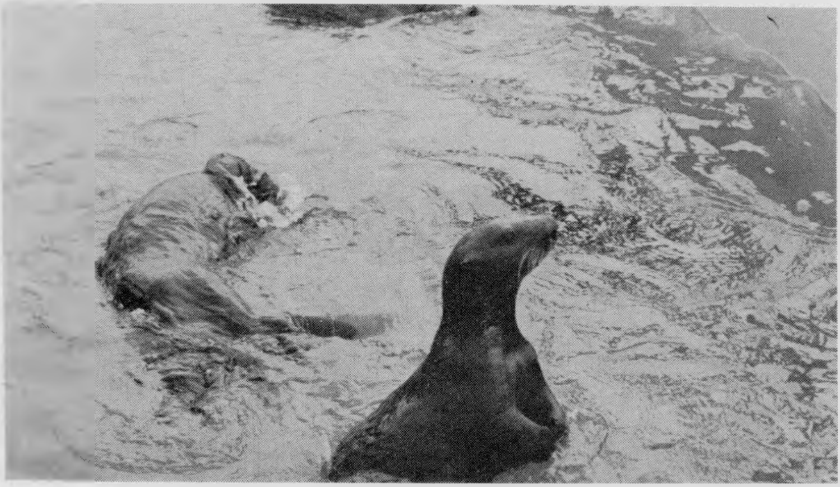


Big Emplacement Holes require big bits and AEC needs at the Central Nevada supplemental test area necessitated the fabrication of this monster 140-inch equipment. Holes are being drilled at 140-inch inside diameter to a depth of several hundred feet, and then at 120-inch inside diameter to depths of 5,000 feet and more. In the background are sections of the largest diameter steel casing ever used for underground nuclear test emplacement holes. It is 122 inches inside diameter with walls ¾-inch thick and is fabricated in 30-foot lengths. The casing for the holes being drilled at the Amchitka, Alaska, supplemental test area is of comparable size.



Microscopically Small Components are also needed for the weapons test program. Photo shows a microminiature lathe being used by a machinist at Bendix's Kansas City, Mo., Division to turn and drill a sleeve so small that it is nearly invisible to the naked eye. The Bendix plant manufactures metallic components for the AEC. The lathe was refitted with ultraprecision bearings to enable the operator to hold the outside diameter at .0048-inch within a tolerance of ±.0001 and concentricity within .00005. Parts are inspected by a light microscope at about 250 magnifications. To establish a size relationship of the part, a completed sleeve has been placed on a hair of a common housefly's face as shown in the *inset* photo. Opposite the fly is the drill bit used to make the hole in the part. Another completed part has been placed on the bit.

"Amchitka National Forest" is shown *above.* The two blue spruce, planted outside the officers' club during military occupation of the island in World War II are the only trees on the remote island. They are being carefully attended by the men engaged in developing the AEC's supplemental nuclear test area on the Aleutian island. In cooperation with the State of Alaska and the U.S. Department of the Interior's Bureau of Sport Fisheries and Wildlife, the AEC transplanted more than 350 sea otters from Amchitka Island to other Alaskan areas not presently occupied by the sea otter. The AEC provided the planes for airlifting the otters to sites near Annette, Sitka, and the Pribilof Islands. The sea otter population at Amchitka, where the AEC is preparing for several underground nuclear tests, exceeds the food resources in that area. Photo *below* shows otters frisking in the Amchitka holding tank while awaiting their plane trip.



Amchitka. Facilities in operation on the southeast end of the island can house and maintain 500 men. An additional 360-man base camp neared completion at year's end. In the northwest part of the island, a road, command post, and an additional 200-man trailer-type camp are being constructed. A facility has been built for unloading cement from ships. Three test emplacement holes are being drilled. Equipment and transport available from the construction activities on Amchitka were also used to relocate nearly 400 sea otters. This program was conducted jointly with the Department of the Interior and the State of Alaska in order to reestablish more colonies of the sea otters in other locales.

ATMOSPHERIC TEST READINESS CAPABILITY

The overseas facilities at Johnston Atoll and in the Hawaiian Islands, the diagnostic aircraft (NC–135), the stockpile of test vehicles, the drop aircraft (B–52), the sampling aircraft and the sampling rocket system, the necessary instruments and instrumentation systems for airborne and ground observation, and allied test equipment have been in readiness since January 1, 1965, and were maintained and improved during 1968. Airdrop readiness exercises, using simulated devices, have been conducted. The exercises maintain and check out the diagnostic capability, increase technical proficiency, and exercise the airborne diagnostic capability.

Diagnostic Aircraft Expedition

A second [5] simultaneous conjugate [6] point study was conducted during the period of March 16 through April 5, 1968, using two of the NC–135 diagnostic aircraft. Such expeditions help to maintain the state of readiness of the diagnostic equipment and personnel as well as provide new scientific information. The primary emphasis of the expedition was to study the degree and extent of point-to-point conjugacy of auroral phenomena and intensities; however, measurements on other aspects of the relationships of solar induced phenomena, cosmic rays, geomagnetic fields, radiofrequency propagation, airglow, and the atmosphere were also performed. Knowledge and experience obtained in all of these areas are applicable to measurement problems and the understanding of effects of nuclear device detonations, both in, and above, the atmosphere.

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[5] See p. 62, "Annual Report to Congress for 1967."

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

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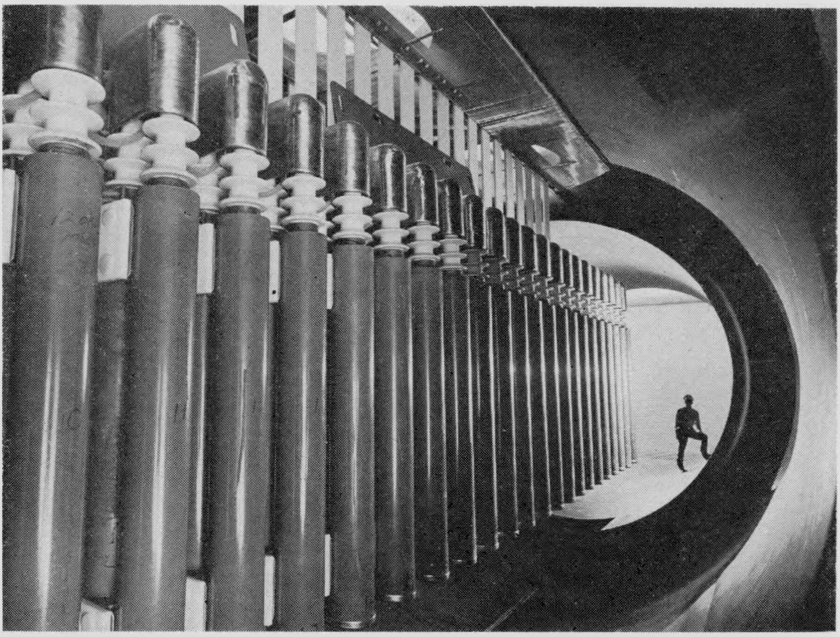
VELA PROGRAM ACTIVITIES

The Vela program is a joint AEC/DOD research and development effort supervised by the DOD's Advanced Research Projects Agency (ARPA) to improve the U.S. capabilities of detecting, locating, and identifying nuclear detonations.

VELA UNIFORM PROGRAM

Both nuclear and chemical explosions are used in the Vela Uniform program to provide the data needed to evaluate the U.S. capability



The World's Newest and Largest X-ray pulse machine will be used to simulate nuclear weapons effects in radiation studies of materials, components, and systems at Sandia Laboratories. Shown is the Hermes II capacitor bank. An 80-foot-long, 20-foot-diameter steel tank, housing the 186 pairs of capacitors and other principal components, is filled with 150,000 gallons of mineral oil for electrical insulation during operation. The capacitor bank of the high-voltage pulse generator of the source is charged to 70,000 volts to store 500,000 joules of electrical energy. The energy is discharged in 100 billionth of a second (100 nanoseconds) at approximately 12 million volts into a planar, electron-accelerator diode, producing a 70-nanosecond X-ray pulse in a tantalum anode. Unprecedented radiation intensities for a laboratory source have been produced. The output of the generator produces a dose in excess of 6,000 *rads* at a distance of 40 inches from the anode.

to detect underground nuclear tests. Five underground nuclear experiments have been conducted under this program, including the Scroll experiment during April.[7]

Project Scroll

Scroll was conducted on April 23, 1968, at the Nevada Test Site under the Crosstie series. The LRL-ARPA experiment was designed to study the seismic decoupling of a tamped detonation in a dry, low density, high porosity medium. It was emplaced in an uncased hole 750 feet deep in an ashfall medium—a form of tuff. Surface seismic data indicated that the decoupling was less than anticipated.

Unmanned Seismic Observatory

The Sandia Laboratory has successfully completed a program, initiated on behalf of ARPA in 1964, for the designing, building, and evaluation of an underground, unmanned seismic observatory (USO).[8] Evaluation of prototypes was conducted in Alaska, Utah, and New Mexico. The equipment from the units has been transferred to the University of Alaska for seismological research purposes.

VELA SATELLITE PROGRAM

The joint AEC-DOD Vela Satellite program continued with preparation for the fifth launching of detection satellites during 1969. The first pair of detection satellites was placed in orbit in 1963. Sandia Laboratory, Los Alamos Scientific Laboratory, and Lawrence Radiation Laboratory, Livermore, worked together on this research and development program to implement Safeguard 4 of the nuclear test ban treaty. Four successful launches have placed eight AEC-instrumented Vela nuclear test detection satellites into near circular coplanar orbits of about 65,000 nautical miles radius. By earth orientation of some of the satellites—the pair launched in 1967 and the additional pair planned for the 1969 launch—it is possible to expand the original space surveillance capability to include atmospheric test detection. The fifth pair of satellites will contain major advances in most areas of instrumentation in keeping with the research and development goals of this program.

The scientific data collected by the Vela satellites in the course of performing their primary mission of test ban monitoring have been of great importance to the scientific community in interpreting solar-terrestrial relationships.

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[7] Vela Uniform events conducted prior to Scroll were: Shoal—Oct. 26, 1963, near Fallon, Nev.; Salmon—Oct. 22, 1964, near Hattiesburg, Miss.; Long Shot—Oct. 29, 1965, on Amchitka Island, Alaska; and Sterling—Dec. 3, 1966, in the Salmon event cavity.

[8] See p. 65, "Annual Report to Congress for 1967."

Chapter 4

NAVAL PROPULSION REACTORS

NUCLEAR FLEET

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

Operating Nuclear Ships

Congress has authorized 108 nuclear-powered submarines, including 41 of the Polaris missile-launching type and one deep submergence research vehicle, as well as seven nuclear-powered surface ships. Of these, 80 nuclear-powered submarines and four nuclear-powered surface ships—the aircraft carrier *Enterprise*, the guided-missile cruiser *Long Beach*, and the guided-missile frigates *Bainbridge* and *Truxtun*—were in operation at year's end and had steamed a cumulative distance of over 12 million miles.

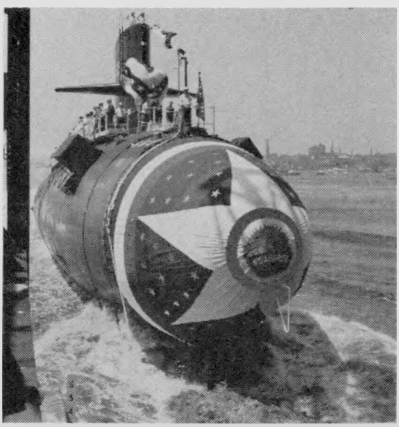
The Navy's fleet of Polaris missile-launching submarines completed its 600th patrol in November 1968. Since the initial Polaris patrol by the *George Washington* (SSBN 598) in November 1960, these 41 nuclear-powered submarines have completed more than 36,500 days of submerged patrol duty or 100 years under water.

The *Bainbridge*, which has completed two Vietnam combat deployments, completed her first overhaul and refueling in May 1968, and returned to the operating fleet. During 1968, the *Truxtun* completed her first Vietnam combat deployment; the *Long Beach* completed her second; and the *Enterprise* completed her third. The operation of these nuclear-powered surface ships continues to demonstrate, under actual combat conditions, the significant advantages of nuclear propulsion for surface warships.

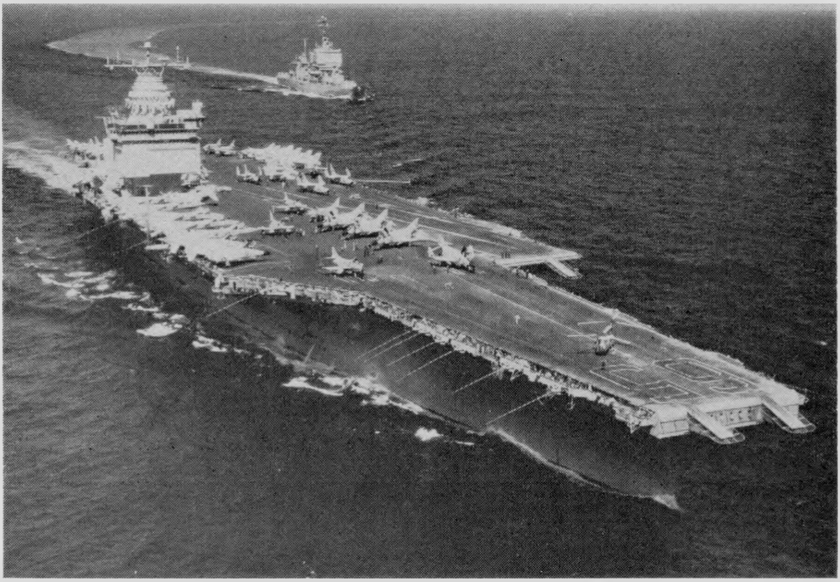
New Surface Ships Planned

In March 1968, the President approved a recommendation by the Secretary of Defense to complete two all-nuclear attack carrier task groups—to build two guided-missile nuclear frigates in addition to those now in operation, to be followed by four nuclear escorts of a new class yet to be designed. A contract for design and construction of the two nuclear-powered frigates (DLGN 36 and 37) was awarded in July 1968. This decision represents a major step in the application of nuclear power to surface escort ships.

A high level of effort continued during 1968 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



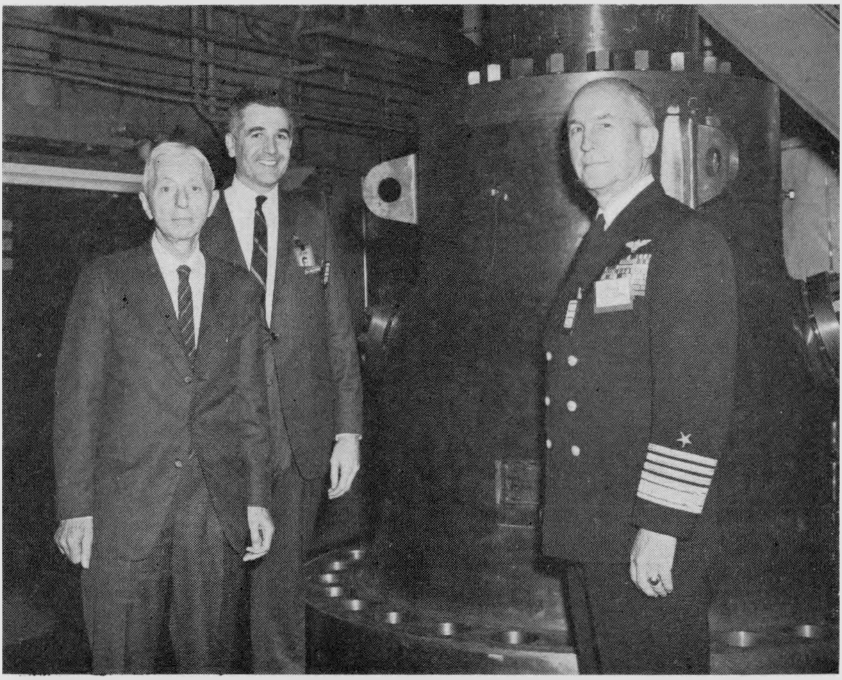
The USS Seahorse (SSN 669), is shown at *left*, as she was launched on June 15. The nuclear submarine was built by the Electric Boat Division of General Dynamics Corp., at Groton, Conn. In photo *below*, the nuclear-powered aircraft carrier *Enterprise* is shown with the nuclear-powered guided missile cruiser *Long Beach*. Operation of these nuclear surface ships, along with the nuclear-powered guided-missile frigates *Bainbridge* and *Truxtun*, continued to demonstrate the significant advantages of nuclear propulsion for surface warships.



which was laid June 22, 1968. Her two reactors are the highest-powered reactors under development in the naval program, each producing about as much power as four of the *Enterprise* reactors. With these two reactors, the *Nimitz* will be able to operate for about 13 years without refueling. In addition to the *Nimitz*, the Department of Defense has indicated its intention of requesting two additional nuclear-powered aircraft carriers in future shipbuilding programs, making a total of three new nuclear aircraft carriers in addition to the *Enterprise.*

Deep Submergence Research Vehicle

A nuclear-powered deep submergence research vehicle, the NR–1, is presently under development. The capability of this submarine—to be manned by a crew of five and two scientists—will be significantly greater than any other oceanographic research vessel developed or



Shown Above is a Test Head used in environmental testing of large reactor core structurals being inspected by Admiral T. H. Moorer (*right*), Chief of Naval Operations, accompanied by Vice Admiral H. G. Rickover (*left*), Director, Division of Naval Reactors, and Mr. N. A. Beldecos, General Manager, Bettis Atomic Power Laboratory. The two reactors for the *Nimitz* (CVAN 68) are the highest-powered reactors under development in the naval reactors program.

planned to date because of the vastly increased endurance afforded by nuclear power. The NR-1 is designed to operate on and near the the ocean bottom for periods of time limited only by the provisions carried on board. Nuclear propulsion in a vessel of this nature provides greater independence from surface support ships and essentially unlimited endurance in propulsion for exploration of the ocean. The NR-1 will provide the capability of exploring an area of the ocean bottom several times as great as the United States and can be used to perform studies and mapping of the ocean bottom, temperature, and currents for military, scientific, and commercial uses.

Nuclear Submarines

In April 1968, the AEC received approval of the Congressional Joint Committee on Atomic Energy to accelerate work on development of the reactor plant for a nuclear-powered submarine capable of higher operating speed than present attack submarines. It is tentatively planned that the first of these higher-speed submarines will be included in the fiscal year 1970 naval shipbuilding program. In October, the Secretary of Defense authorized the Navy to proceed with construction of a turbine electric drive submarine. The contract to initiate construction of this new submarine was awarded during December.

Throughout 1968, the AEC continued to emphasize research and development work on advanced naval reactor cores of greater reliability, higher power, and longer life. Cores now being installed in nuclear submarines will last for more than 10 years of normal operation and propel the ship for approximately 400,000 miles.

Chapter 5

REACTOR DEVELOPMENT AND TECHNOLOGY

ASSESSMENT OF NUCLEAR POWER

In 1968, electric utilities contracted for 17 nuclear power stations, thus making a total, at the end of the year, of 91 central station nuclear power reactors with a net capacity of 65,482 Mwe. (megawatts of electricity) under contract, under construction, or in operation. (See tables 1 and 2.) By 1980, it is estimated that 20 to 30 percent of the electrical generating capacity in the United Staes will be nuclear, and by the year 2000 the nuclear capacity will represent about 50 percent of the total. For comparison, in 1965 less than 1 percent of the electricity in the United States was generated by nuclear plants.

Personnel Requirements

More than 5,000 highly trained people will be needed to staff the nuclear powerplants expected to begin operation within the next 8 years (see chart, p. 77). During the same period, many others with nuclear training and experience will be required by utility plant owners for technical support, as well as by the reactor designers and manufacturers and other nuclear power segments of Government, industry and universities. During 1968, through conferences, speeches and correspondence, and meetings with representatives of the nuclear industry, the AEC continued its efforts to alert newcomers to the nuclear energy program of the urgent need to obtain and train their personnel. Early action to achieve thorough in-house competence is needed because of the unique design and operating characteristics and safety requirements of nuclear powerplants, and because of the increasingly competitive demand for qualified personnel.

Program Assessed

Recognizing that the requirements for reactor development are continuously changing, the AEC, in cooperation with its laboratories and the nuclear industry, has been formally reviewing and assessing the program for developing civilian nuclear power reactors.

Developments in the program since 1962—when one of the first full-scale assessments was made—and the AEC's objectives, policies, and procedures affecting the future reactor development efforts were included in a report issued in 1967.[1] The report also served as background for more detailed technical and economic evaluations by special task forces. Two task force reports were completed in 1968; the

[1] "Civilian Nuclear Power—1967 Supplement of the 1962 Report to the President," for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $0.40.

TABLE 1.—NUCLEAR STEAM SUPPLY SYSTEM CONTRACT AWARDS—U.S. CENTRAL STATION PLANTS
(No. of units/net Mwe.)

Nuclear Contractor	Through 1965		1966		1967		1968		Totals*	
	No.	Mwe.	No.	Mwe.	No.	Mwe.	No.	Mwe.	No.	Mwe.
General Electric	8	3,345.9	9	7,389.6	8	6,911.5	9	8,142.0	34	25,789.0
Westinghouse	9	3,580.5	6	4,793.6	13	10,505.4	5	5,283.0	33	24,162.5
Babcock & Wilcox	1	265.0	3	2,513.2	5	4,131.1	3	2,130.0	12	9,039.3
Combustion Engineering	1	16.5	2	1,157.4	5	4,018.0	0		8	5,191.9
Other	9	1,437.8	0		0		0		9	1,437.8
Totals*	28	8,645.7	20	15,853.8	31	25,566.0	17	15,555.0	96	65,620.5

*See footnote 2 under Table 2.

TABLE 2.—ACHIEVEMENT OF INITIAL DESIGN POWER [1]

Year	Megawatts of electricity net		Number of plants	
	Annual	Cumulative	Annual	Cumulative
Thru 1968 [2]	2,841.2		17	
1969	3,578.0	6,419.2	7	24
1970	4,941.8	11,361.0	7	31
1971	9,062.0	20,423.0	12	43
1972	12,089.4	32,512.4	15	58
1973	15,038.1	47,550.5	18	76
1974	10,300.0	57,850.5	12	88
1975	4,832.0	62,682.5	5	93
1976	821.0	63,503.5	1	94
1977	2,117.0	65,620.5	2	96

[1] Based on October 1968 schedule information reported by utilities for nuclear plants contracted for as of December 31, 1968.

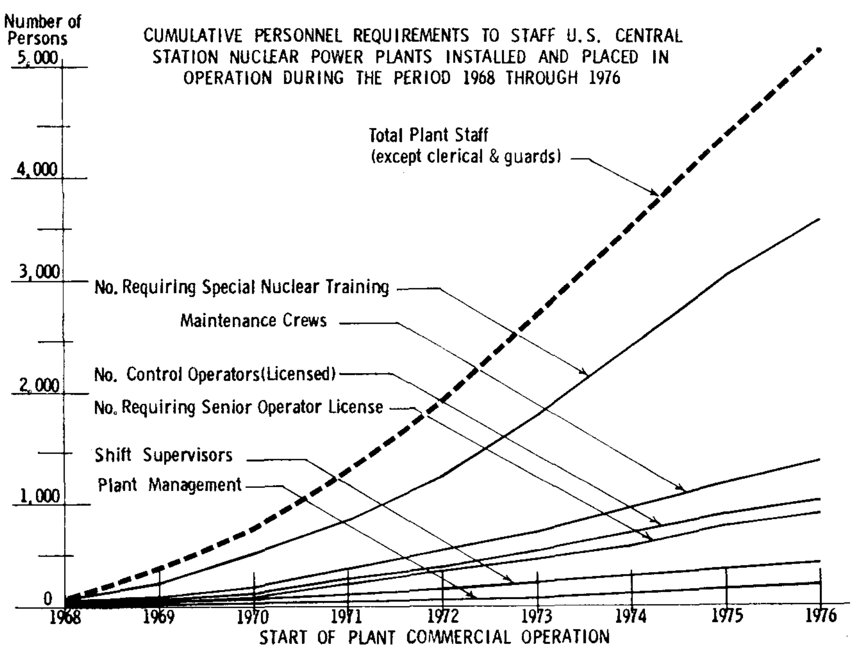
[2] Includes 5 plants which achieved design power but have since been permanently shutdown: Hallam (75 Mwe.); Piqua (11.4 Mwe.); CVTR (17 Mwe.); BONUS (16.5 Mwe.) and Pathfinder (58.5 Mwe.).

others are to be completed in 1969 (see table 3). The two reports now available are: "Current Status and Future Technical and Economic Potential of Light Water Reactors," and "An Evaluation of Heavy Water Moderated Organic-Cooled Reactors." Other task forces have been evaluating advanced converter reactors, liquid metal fast breeder reactors, alternate coolants for fast breeder reactors, thorium systems, and fuel recycling. Potential nuclear power growth patterns are being identified and projected by a systems analysis task force.

These special studies are expected to be of general value to both Government and industry in long-range planning and development of nuclear power reactors and their use in the power systems of the United States.

BREEDER REACTOR DEVELOPMENT

With few exceptions, orders by utilities have been for nuclear powerplants with light water (pressurized or boiling water) reactors. Although anticipated to be economically competitive with fossil-fueled plants, these reactors have limitations on the amount of available energy in uranium which they can extract.



The primary objective of the civilian power reactor development program is to foster and support the growing use of nuclear energy for the production of heat and electricity while fully exploiting the energy available in the nation's nuclear resources.

Widespread use of nuclear power can be projected by the present trend of orders for nuclear plants, but to obtain the latter part of the program's objectives, breeder reactor development is required.

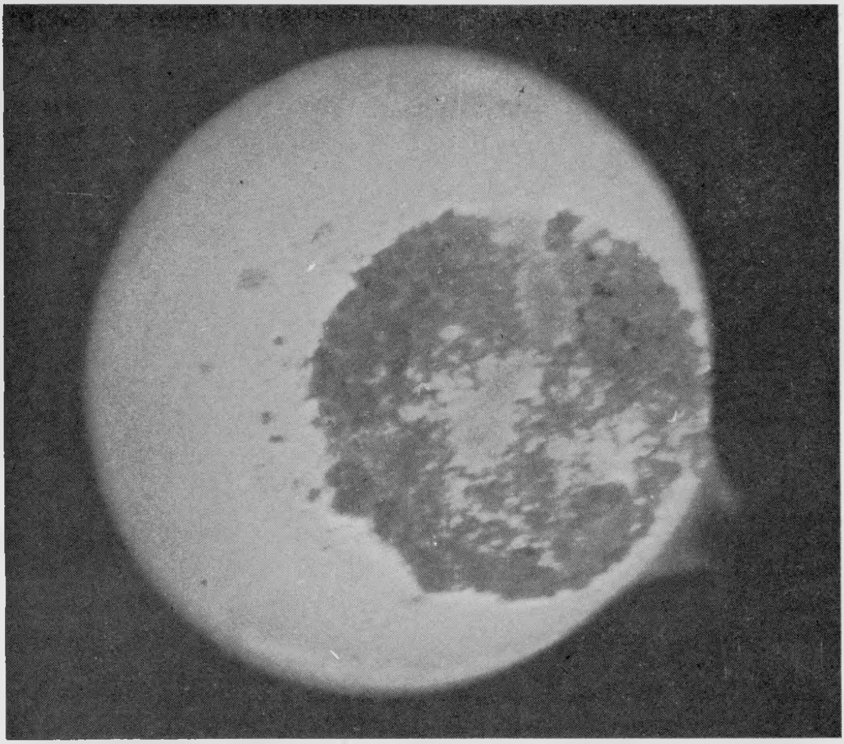
TABLE 3.—CIVILIAN REACTOR PROGRAM TASK FORCE REPORTS

Title (and number)	Task force participants
"Current Status and Future Technical and Economic Potential of Light Water Reactors" (WASH-1082 [1]).	Light Water Reactors: Representatives of S. M. Stoller Associates (S.M.S.), New York City, and Jackson and Moreland Div. (J&M), United Engineers and Constructors, Boston, Mass.; Babcock & Wilcox Co. (B&W), Atomic Energy Div., Lynchburg, Va.; Combustion Engineering, Inc. (CE), Windsor, Conn.; General Electric Co. (GE), Advanced Product Operation, Sunnyvale, Calif.; Westinghouse Electric Corp. (West.) Advanced Reactor Div., Pittsburgh, Pa.
"An Evaluation of Advanced Converter Reactors" (Summary) (WASH-1087). "An Evaluation of Heavy-Water-Moderated Organic-Cooled Reactors" (HWOCR) (WASH-1083 [1]). "An Evaluation of High Temperature Gas-Cooled Reactors" (HTGR) (WASH-1085).	Advanced Converters: Gulf General Atomic (GGA), San Diego, Calif.; B&W; CE, Atomics International (AI), Canoga Park, Calif.; Oak Ridge National Laboratory (ORNL); Brookhaven National Laboratory (BNL); Pacific Northwest Laboratory (PNL); Los Alamos Scientific Laboratory (LASL).
"An Assessment of the Liquid Metal Fast Breeder Reactor (LMFBR) Program" (WASH-1100).	Liquid Metal Fast Breeder Reactors: Argonne National Laboratory (ANL), LASL, B&W, GE, West., CE, AI, Power Reactor Development Co., Monroe, Mich.
"An Evaluation of Alternate Coolant Fast Breeder Reactor" (Summary) (WASH-1090). "An Evaluation of Steam-Cooled Fast Breeder Reactors" (SCBR) (WASH-1088). "An Evaluation of Gas-Cooled Fast Breeder Reactors" (GCFR) (WASH-1089).	Alternate Coolants: ORNL, GE, West., B&W, GGA, LASL, PNL, ANL.
"The Use of Thorium in Nuclear Power Reactors" (WASH-1097).	Thorium Systems: ANL, BNL, B&W, GGA, ORNL, PNL.
"Reactor Fuel Cycle Costs for Nuclear Power Evaluation" (WASH-1099).	Fuel Recycle: ORNL, ANL, PNL, Idaho, Savannah River Laboratory, GE, West., S.M.S., Nuclear Fuel Services, Wheaton, Md., Allied Chemical, Morristown, N.J.
"Potential Nuclear Power Growth Patterns" (WASH-1098).	Systems Analyses: PNL, CE, AI, GGA, B&W, LASL, ANL, BNL, ORNL, GE, West.

[1] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $2.25 for (WASH-1082) and $1.50 for (WASH-1083).

Breeder Concept

In breeder reactors, excess neutrons obtained during plant operations are used to produce more fissionable material than is consumed, while, at the same time, the plant is generating power. The fissionable isotopes—uranium-233 and -235 (U^{233} and U^{235}) and plutonium-239 and -241 (Pu^{239} and Pu^{241})—all produce more neutrons than are



This "Large" Sample of Protactinium-233 (dark circular area in the photo) was photographed in the light from its own radioactive emission (the lighter area) at the National Reactor Testing Station in Idaho. The rare specimen (about twice actual size, as shown here) was obtained by irradiating thorium-232 for 5 weeks in the highest flux position of the Materials Testing Reactor (MTR). The protactinium was isolated for continuing studies of the feasibility of converting relatively inexpensive thorium into the valuable reactor fuel uranium-233; protactinium-233 is an intermediate step in this conversion process. Thorium can be used in the fuel loadings for the Light Water Breeder Reactor and Molten Salt Reactor concepts—when the photo was taken, the activity of the 1.4-gram sample of protactinium was approximately 25,000 curies, or 25,000 times as much activity as one gram of radium. (The protactinium, with a half-life of 27½ days, was disintegrating at the rate of 900 trillion atoms per second.) The MTR is operated for the AEC by Idaho Nuclear Corp.

needed to maintain a nuclear chain reaction. Therefore, breeder reactors are designed so that the excess neutrons are absorbed either in U^{238}, leading to the production of Pu^{239}, or in thorium, leading to the production of U^{233}.

Breeder reactors can extend ore reserves by using from 60 to 90 percent of the uranium mined compared with the present utilization of about 1 percent have potential lower total energy costs, and will be able to use for fuel the plutonium produced in present light water reactors. Therefore, the AEC's civilian power reactor development effort is concentrating on breeder reactors, with priority given to the liquid metal fast breeder reactors (LMFBR).

LMFBR PROGRAM

The objective of the AEC-sponsored liquid metal fast breeder reactor (LMFBR) program is to achieve through research and development the technology and materials which will make possible the design, construction, and operation of safe, reliable, and economic fast breeder reactors in central station nuclear powerplants.

During 1968, the AEC distributed a comprehensive LMFBR program plan [2] to industry, utilities, and laboratories; achieved further involvement of industry and the national laboratories in the program; continued the construction and modification of the experimental and test facilities which will provide the materials and data required for the successful achievement of the program objective; and carried on a basic LMFBR technology program.

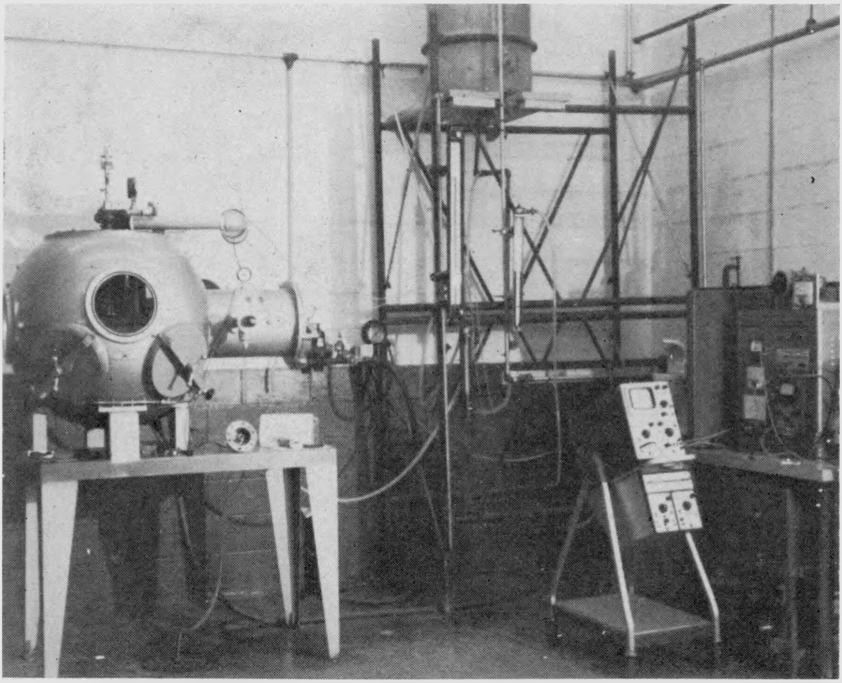
LMFBR Program Plan

The AEC has had a limited experimental development program for LMFBR's for approximately 20 years. However, moving such a general program to the forefront of the national reactor development effort required several major steps. One of the first steps was the preparation of the LMFBR program plan which began in 1966 when the LMFBR program office was established at Argonne National

[2] "LMFBR Liquid Metal Fast Breeder Reactor Program Plan." Volumes 1–10. Vol. 1, "Overall Plan"; Vol. 2, "Plant Design"; Vol. 3, "Components"; Vol. 4, "Instrumentation and Control"; Vol. 5, "Sodium Technology"; Vol. 6, "Core Design"; Vol. 7, "Fuels and Materials"; Vol. 8, "Fuel Recycle"; Vol. 9, "Physics"; and Vol. 10, "Safety"; available from Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va., 22151. Price: $3.00 for each volume.

Laboratory to assist the AEC Headquarters staff in this planning function. The plan is the result of many months of discussions, reviews, and assessments by the AEC, the LMFBR program office, the national laboratories, the nuclear industry, and the electric utilities. The total plan includes nine technical program areas (see footnote 2, p. 80).

Implementation of the LMFBR program plan is underway. For example, an essential part of successful LMFBR plant design is an identification of the requirements and evaluation of the problems. Therefore, several LMFBR plant design studies have been undertaken; 1,000 Mwe. design studies by five industrial contractors—Atomics International, Babcock & Wilcox, Combustion Engineering, General Electric, and Westinghouse—were essentially completed in 1968. The designs and the identification of the research and development programs required for detailed design and construction of safe,



The First High-Speed Centrifuge capable of continuously processing molten sodium to remove particulate impurities from the liquid metal has been developed by Atomic Power Development Associates, Inc., Detroit, Mich., under contract to the AEC. Initial operation was in June 1968, during which carbon and metallic particulates were removed, and demonstrated the feasibility of the process. Because the centrifuge must operate in an inert gas environment, it is located within a spherical glove box. The parts of the centrifuge bowl can be seen at the *right* edge of the glove box table. Instrumentation is at *right* of photo.

reliable, and economic 1,000 Mwe. LMFBR plants for the 1980's will continue to be documented. Evaluation of these designs and the research and development programs that will be required is being done at Argonne National Laboratory. Tasks for LMFBR safety studies and more in-depth plant design studies are being assigned to several AEC contractors.

Industry and Utility Participation

Concurrent with AEC-funded work, there has been considerable privately funded activity on the part of the nuclear industry leading to the development of fast breeder reactors. The extent of this activity is reflected in table 4 which was prepared by the Edison Electric Institute.[3]

Reactor plant manufacturers have been strengthening their competitive position in LMFBR development by increasing their technical staffs and manufacturing capabilities and by allocating significant amounts of money specifically for LMFBR work.

For example, Westinghouse created a new advanced reactors division at Pittsburgh, Pa., and committed itself to building about $12 million worth of facilities; Westinghouse plans a $50 million corporate investment in LMFBR work over a 3-year period. General Electric has been expanding its facility at San Jose, Calif., for sodium development work; and Babcock & Wilcox has reorganized and centralized its LMFBR work at Lynchburg, Va.

LMFBR Test and Experimental Facilities

Liquid Metal Engineering Center

The Liquid Metal Engineering Center (LMEC) at Canoga Park, Calif., operated by Atomics International (AI), is an engineering complex of component test facilities with supporting chemical, metallurgical, and instrumentation laboratories for testing and evaluating instrumentation, equipment, and components such as steam generators, valves, pumps, and flow meters for fast breeder reactors. In addition, the LMEC provides technical assistance and consultation services to the AEC, and has resources for conducting technical training programs for personnel from LMFBR contractors and utilities. It also has a Liquid Metal Information Center which compiles, assesses, and disseminates sodium technology information.

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[3] "Fast Breeder Reactor Report," Edison Electric Institute, 750 Third Ave., New York, N.Y. 10017.

TABLE 4.—ELECTRIC-UTILITY-SUPPORTED FAST BREEDER DEVELOPMENT

Utilities [1]	Designer [1]	Concept	Objective	Schedule	$1 Millions
Projects involving reactor construction					121
PRDC—DE	APDA	Sodium-FERMI.	Power demonstration project.	1955—Startup-August 1963.	115
SAEA	GE	Sodium-SEFOR.	Confirm PuO_2-UO_2 fueled core safety—*Doppler* coefficient.	1964–71 startup-mid 1968.	5.9
Projects involving studies and R. & D.					15.8
EEI—DE	APDA	Sodium	Demonstrate PuO_2-UO_2 fuel performance in operating reactor.	Phase 1 February 1966–December 1966.	0.8
PG&E, DE, CE, DP, SAEA	GE	Sodium	Demonstration plant design study to provide basis for commitment.	February 1967–February 1969.	0.75
DE, CE, DP, CA, HL&P, NU, SCE&G, APSC, plus Others	West.	Sodium	Demonstration plant study to help establish its technical basis.	April 1967–April 1970.	[2] 1.0
ESADA	AI	Sodium	Support of large FBR design study to help direct future development.	1967–68	0.1
ESADA	GE	Sodium	Develop key components and systems required to assure demonstration plant operation in 1975.	August, 1967–August, 1970.	5.0
GPU	AI	Sodium	Develop design and technical basis for construction of demonstration plant.	1967–70	[2] 5.0
ESADA	GE	Steam	Provide conceptual design of large plant.	1967–68	0.1
ECNG—AEP	GE	Steam	Develops conceptual design of 50-Mwe. experiment and establish its feasibility.	March 1967–March 1968.	1.2
ECNG—AEP	B&W	Steam	Conceptual design of supercritical pressure steam cooled system.	1963–65	1.0
ECNG—AEP	CGA	Gas	Provide 1,000-Mwe. reference design for technical and economic assessment.	August 1965–December 1966.	0.75

[1] Companies, Organizations: AEP—American Electric Power Co.; AI—Atomics International; APDA—Atomic Power Development Assoc.; APSC—Allegheny Power Service Co.; B&W—Babcock & Wilcox; CA—Commonwealth Associates; CE—Combustion Engineering, Inc.; DE—Detroit Edison Co.; DP—Duke Power Co.; ECNG—East Central Nuclear Group; EEI—Edison Electric Institute; ESADA—Empire State Atomic Development Assoc., Inc.; GE—General Electric Co.; GGA—Gulf General Atomic; GPU—General Public Utilities Corp; HL&P—Hartford Light & Power Co.; NU—Northeast Utilities Co.; PG&E-Pacific Gas & Electric Co.; PRDC—Power Reactor Development Co.; SAEA—Southwest Atomic Energy Assoc.; and SCE&G—South Carolina Electric & Gas Co.

[2] Estimates only; the actual amounts have not been announced.

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There are three testing facilities in use, and one being designed:

(*1*) The Control Rod Test Tower is used for proof-testing reactor control rod assemblies.

(*2*) The Sodium Components Test Installation initially was placed in operation in 1966, and preliminary tests were conducted which involved small components. Significant design changes were made during 1967 and 1968 to permit performance test operations, starting in 1969, on steam generators and intermediate heat exchangers.

(*3*) The Large Components Test Loop is currently in operation for the testing of sodium reactor system components, small valves, equipment and instruments in support of the Fast Flux Test Facility project to be located near Richland, Wash., as well as other sodium instruments and small components of the LMFBR program. Concurrent with present operation, design work is being carried out to modify the facility to permit increased test flexibility.

(*4*) A Sodium Pump Test Facility is being designed by C. F. Braun & Co., Alhambra, Calif., for location at the LMEC. The facility will provide means for proof testing large pumps, valves, and other components using sodium at temperatures up to 1,200° F.

In support of the sodium pump development program, sodium pump seal test rigs for proof testing sodium pump seals were erected during 1968, and seals are to be ordered for test in 1969.

New chemistry and metallurgy laboratories became operational in 1968 and are being used in support of the component and instrumentation proof-testing activities of the center.

In addition, during 1968 the center's staff continued to prepare standards and specifications for the program, conducted special design studies, and prepared technical reports, evaluations, and recommendations for use in planning future LMFBR activities.

Experimental Breeder Reactor No. 2

The Experimental Breeder Reactor No. 2 (EBR–2) at the National Reactor Testing Station (NRTS) in Idaho is being used as a fast flux test facility for irradiating fuels and materials for the LMFBR program. EBR–2 was originally designed as an experimental reactor, but modifications have been and are being made to increase its usefulness as an irradiation facility.

As a result of the use of special surveillance procedures, improved operating and maintenance procedures, increased fuel supply, and plant modifications, significant improvement in plant-use time was achieved in 1968 compared to that achieved in 1967. Further modifications are being made in the plant to enhance its use for the LMFBR effort.

Operating power for the EBR–2 was increased from 45 Mwt. (thermal megawatts) to 50 Mwt., further increasing the irradiation capability of the reactor. Studies are in progress to expand the EBR–2 core to provide even greater irradiation capacity.

A "hot" (irradiated) fuel examination facility is to be constructed as part of the EBR–2 complex to provide for examining irradiated experiments essential to the development of fuels, fuel cladding, and structural materials, principally for fast breeder reactors. Norman Engineering Co., Los Angeles, Calif., has been selected as the architect-engineer.

Fast Flux Test Facility

The Fast Flux Test Facility (FFTF) reactor, with a design power level of 400 Mwt., will provide a versatile test capability in a fast neutron environment typical of that expected in commercial fast breeder reactors. The FFTF will be the AEC's major fuels and materials test irradiation facility in the LMFBR program, and is scheduled to be in operation near Richland, Wash., in 1974.

During 1968, the Bechtel Corp., San Francisco, Calif., was selected as architect-engineer responsible for general plant design. Westinghouse (Advanced Reactor Division) was selected as the prime contractor for the reactor plant design, with Atomics International (AI), Canoga Park, Calif., as the principal subcontractor. Westinghouse, as the overall designer for the reactor plant, will perform the work under subcontract to Pacific Northwest Laboratory (PNL), which has overall system management responsibility for the FFTF.

PNL, AI, and Westinghouse have been involved in efforts to determine the best reactor concept to meet the diverse and unique demands of irradiation testing, instrumentation, and availability in the FFTF.

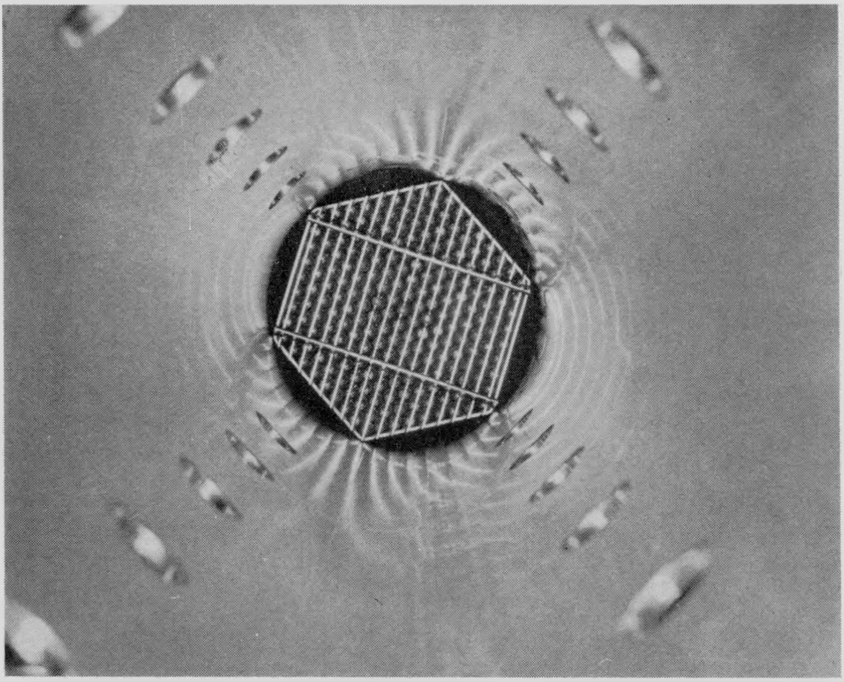
Design of the FFTF has progressed through the development of a technical design, including the selection of a site, basic operating and design characteristics, and overall functional test capabilities. The testing capability of this reactor will be superior to that of any other test reactor in the world since its fast flux will be more than double that of any such facility.

Fast Breeder Reactor Physics

The AEC is carrying on an extensive fast breeder reactor physics program. These data are essential for the design and operation of safe and economic fast breeder reactors.

The primary facilities for this program are the Zero Power Reactor No. 3 (ZPR–3) and the Zero Power Plutonium Reactor (ZPPR) at the NRTS, and the Zero Power Reactor No. 6 (ZPR–6) and the Zero Power Reactor No. 9 (ZPR–9) at Argonne National Laboratory.

During 1968, ZPR–3's operation included an examination of various fuel arrangements for the FFTF reactor; ZPR–6 and 9 were shut down in June for modifications to accommodate plutonium fuel load-



This Conceptual Model of a Fast Flux Test Facility (FFTF) driver fuel subassembly and fuel duct was developed by the Pacific Northwest Laboratory, for flow testing in the Core Components Test Loop (CCTL) at Argonne National Laboratory. The duct, slightly modified from actual FFTF design to fit in the CCTL, is made of austenitic stainless steel. The holes radiating out from the fuel subassembly are exit ports for the flowing sodium. The fuel subassembly (grid at *center*) contains 217 fuel pins, ¼-inch in diameter and, in this case, contain uranium dioxide (UO_2). The FFTF, to be built near Richland, Wash., will be a major tool for testing fuels and materials being considered for use in liquid-metal-cooled fast-breeder power reactors.

ings. Modifications and check-out of the facilities will begin in early 1969.

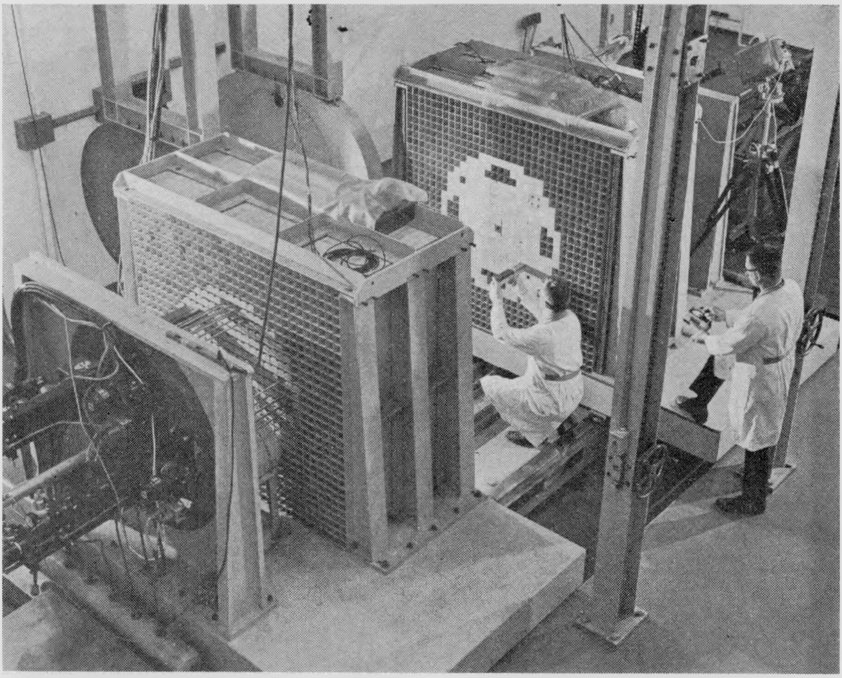
Construction of the ZPPR has been completed and the facility is now undergoing final pre-operational check-out.

The order for ZPPR fuel, the largest single contract for commercial production of plutonium-containing fuel, involving over 2,000 kilograms of plutonium, was delivered by Nuclear Materials and Equipment Corp., Apollo, Pa., ahead of schedule.

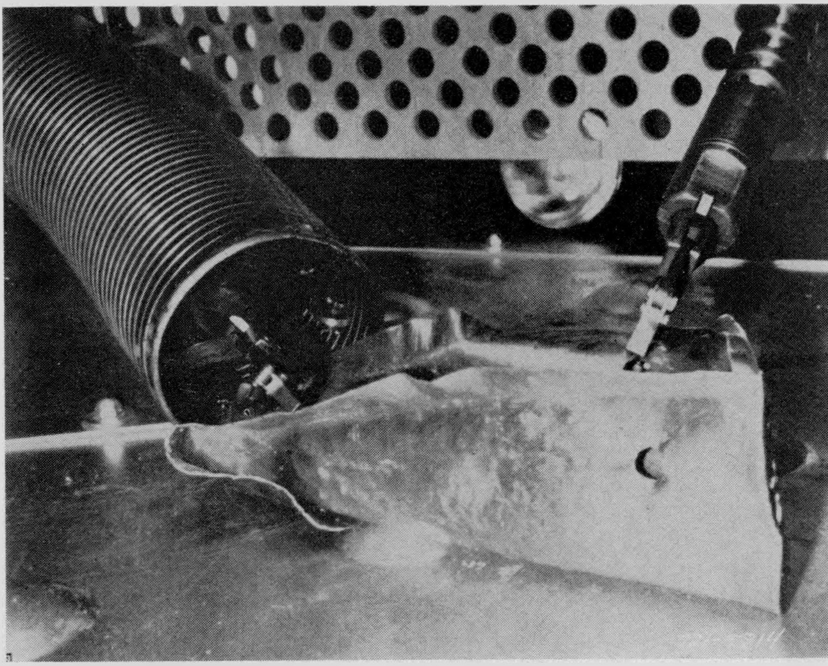
Other Breeder Reactors

Fermi Atomic Power Plant

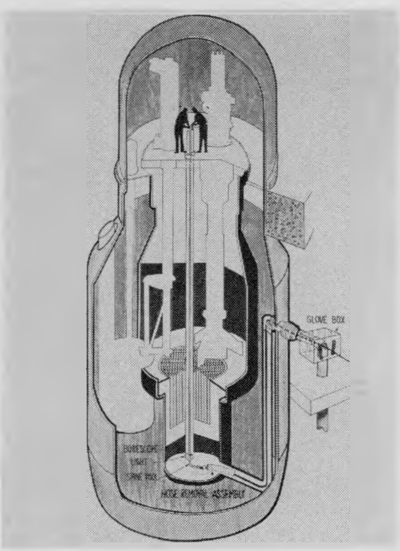
The Enrico Fermi Atomic Power Plant at Lagoona Beach, Mich.—the nation's first privately owned fast neutron breeder reactor—remained shut down during 1968 for repairs following a partial fuel

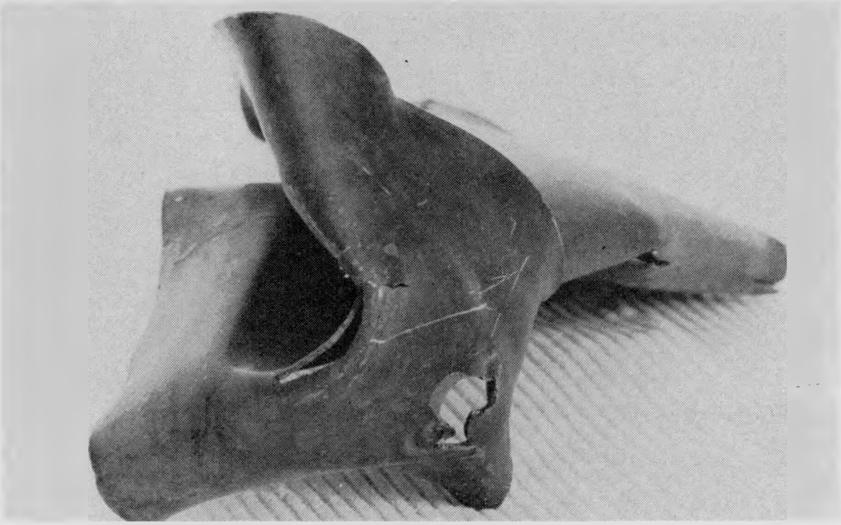


As One Technician Removes one of the fuel elements from one-half of the Split Table Critical Assembly in the Epithermal Critical Experiments Laboratory at Atomics International, Canoga Park, Calif., the other monitors its radioactivity level. The machine is used to conduct fast reactor experiments for the AEC's fast breeder reactor physics program as a means to improve the understanding of the interaction of fast neutrons with various reactor materials.

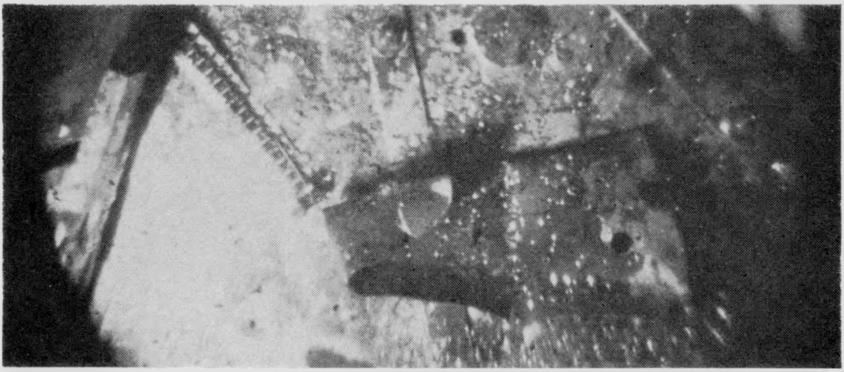


Retrieval of the Zirconium Sheet Segment (shown on *opposite* page) that blocked the flow of sodium coolant in the Fermi reactor was a first-of-its-kind operation. Once the blockage location had been determined, a full-scale mockup of that part of the reactor was used to determine the special tools and procedures necessary for the work. Photo *above*, taken in the mockup of the Fermi reactor vessel inlet plenum, shows special tools used to remove object from the plenum through one of the 14-inch diameter sodium inlet pipes. Drawing at *left* is artist's concept of the method used to remove object from the reactor. Using special lights, a borescope, and articulated tools, the object was picked up in the plenum approximately 35 feet down, transferred to the hose removal assembly, and pulled out the 14-inch inlet pipe. The primary sodium was drained from the vessel prior to performing the removal operations.





This Segment of 40-Mil Zirconium Sheet, above, was the object causing the Fermi reactor's partial fuel meltdown incident of October 1966. The segment was originally a flat triangular shape, approximately 12 inches on the base and 16 inches high. It was attached in position in the inlet plenum below the reactor core by bolts on each of the three corners. The photograph shows the deformation of the segment as it was removed from the reactor on March 22, 1968. The distortion was probably caused by forces from the flowing coolant after the segment became detached from one of the bolts. One of the corner bolt holes can be seen in the photograph. The segment eventually blocked several fuel coolant inlet passages, causing partial meltdown of several subassemblies. Photo *below* was taken of the object while it was still in the sodium inlet plenum of the Enrico Fermi fast reactor. The sodium was drained from the reactor vessel and this picture was taken 35 feet down in the plenum using specially designed lights, borescope, and camera equipment. Photos such as this were used to determine the method of retrieval as shown on the *opposite* page.



meltdown on October 5, 1966. During 1968, a zirconium sheet segment was identified as the object which had torn loose from its position in the sodium inlet plenum chamber below the reactor and blocked the flow of coolant. This apparently caused the fuel to overheat and melt. The zirconium sheet was removed from the reactor by special tools, and removal of the five remaining zirconium sheets was completed by the end of 1968. Plans were made to begin loading the reactor with new fuel by May 1969.

The contract under the AEC's Power Reactor Demonstration Program [4] between the Power Reactor Development Corp. and the AEC expired on May 8, 1968.

Molten Salt Reactor Experiment

On October 2, 1968, the Molten Salt Reactor Experiment (MSRE) at the Oak Ridge National Laboratory became the world's first reactor known to operate on a loading of uranium-233 (U^{233}) fuel. The U^{233}, a manmade form of uranium, is fissionable like the uranium-235 (U^{235}) which fueled the reactor previously. The MSRE is scheduled to operate at a power level of 8,000 thermal kilowatts with the U^{233} fuel.

Operation of the MSRE is providing experience and data needed to evaluate the practicability of molten salt reactors—a circulating fluid fuel reactor having a breeding potential—and operation with U^{233} will determine the technical and economic feasibility of using thorium-uranium fuel in the molten salt-type reactor in which atoms of nonfissionable thorium are converted, or "bred," into fissionable atoms of U^{233}. Thorium-bearing minerals are found principally in granite, which is widespread over the earth.

In addition to operation of MSRE, ORNL is conducting a base technology effort to investigate the key engineering problems associated with introducing this concept into the industrial-utility environment. This work includes conceptual design studies of a 1,000-Mwe. molten salt breeder reactor powerplant and intensive investigations of fuel processing.

Gas-Cooled Fast Reactors

Since 1963, the AEC has supported studies on gas-cooled fast reactors (GCFR), primarily in the area of fuel-development work at Oak Ridge National Laboratory and at Gulf General Atomic, San Diego,

[4] Under Power Reactor Demonstration Program (PRDP) contracts, the AEC provides various types of assistance to industry in return for which technical and economic data are made available to the AEC for use by industry and the AEC in further development of nuclear power.

Calif. In addition to the fuel development efforts, AEC-supported work at Gulf General Atomic has included core development plans, conceptual design work on a gas-cooled fast reactor experiment, studies of a Fast Flux Test Facility (FFTF) gas loop, and work on a joint East Central Nuclear Group-Gulf General Atomic 1,000-Mwe. GCFR plant design for inclusion in the AEC study on alternative coolants for fast breeders.

Light Water Breeder Reactor

During 1968, fabrication began on 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. Development work on LWBR is being carried out at the AEC's Bettis Atomic Power Laboratory, Pittsburgh, Pa.

The Light Water Breeder Reactor, which uses the seed-blanket reactor concept along with the thorium-uranium-233 fuel cycle, is the only known approach for significantly improving fuel utilization of light water reactors. The LWBR breeding demonstration is expected to provide the basic technology which could make available for power production about 50 percent of the energy in U.S. thorium reserves, a potential source of energy many times greater than known fossil fuel reserves. This would represent a tremendous increase in resource utilization compared to about 1 percent in present types of light water reactors. A successful demonstration of breeding in a light water reactor would demonstrate the technology which would allow building new light water breeder reactors and converting present and future pressurized water reactors to breeders.

OTHER REACTOR CONCEPTS

During 1968, the AEC continued support for certain other reactor concepts, including projects for which there were prior commitments for specified research and development tasks. In addition, the AEC base program includes research, development, and testing directed toward reactor safety, and a limited investigation of plutonium recycle in these reactors.

WATER REACTORS

Connecticut Yankee

The Connecticut Yankee Atomic Power Plant originally reached full power of 490 Mwe. (gross) on December 29, 1967, and started commercial operation on January 1, 1968. Except for some short shutdowns for maintenance, mostly on the conventional portion of the plant, Connecticut Yankee has been on line almost continuously, producing over 3½ billion kilowatt hours during 1968.

San Onofre Nuclear Generating Station

The 430-Mwe. San Onofre Nuclear Generating Station with its pressurized water reactor, located at San Clemente, Calif., first produced electricity in July 1967. The plant was shut down in March 1968 when a fire broke out in the 480-volt switch gear room. Repairs were completed and the reactor again attained criticality on September 8, 1968. The plant resumed power operation later in September.

Elk River Reactor

The Elk River Reactor at Elk River, Minn., which first sustained a nuclear chain reaction in 1964 and operated through 1967, was shut down in February 1968 because of leakage from the primary reactor system. The plant remained shut down through 1968 and existence of the leak source located; repair planning was initiated.

Elk River is a boiling water reactor plant built under the Power Reactor Demonstration Program. It has a fossil-fueled superheater which boosts the electric generating capacity of the plant from approximately 16 to 22 Mwe.

LaCrosse Reactor

The LaCrosse Boiling Water Reactor (LACBWR), Genoa, Wis., which had achieved a nuclear chain reaction in July 1967, was shut down May 30, 1968, because of equipment malfunctions during test operations. The plant remained out of service until the latter part of 1968 for plant and equipment repairs, and modifications. Power testing resumed, with completion of the warranty run scheduled for March 1969.

GAS COOLED REACTORS

Peach Bottom Atomic Power Station

The 40-Mwe. Peach Bottom prototype high temperature gas-cooled reactor in Pennsylvania operated at essentially full power during periods of the greatest demand for electricity. The reactor was shut down from mid-January to May for the first of six tests required by the AEC at the end of 150 equivalent full days of operation. During the remainder of the year, the reactor ran with a plant factor of about 82 percent. The fission product activity level in the helium coolant rose during operation to a level of 34 curies, well below the design level of 4,000 curies, but this indicated that there was some fuel element failure. The Philadelphia Electric Co. continued plant operations to achieve 300 full power days. The plant then was shut down for inspection and maintenance and selective discharge of fuel as required by the license specification. On October 23, the reactor was shut down for the second technical specification inspection period. Examination showed that 11 of 804 fuel elements were broken and releasing activity to the coolant. At the end of 1968, removal of the fuel elements was still underway, with resumption of operation scheduled for early 1969.

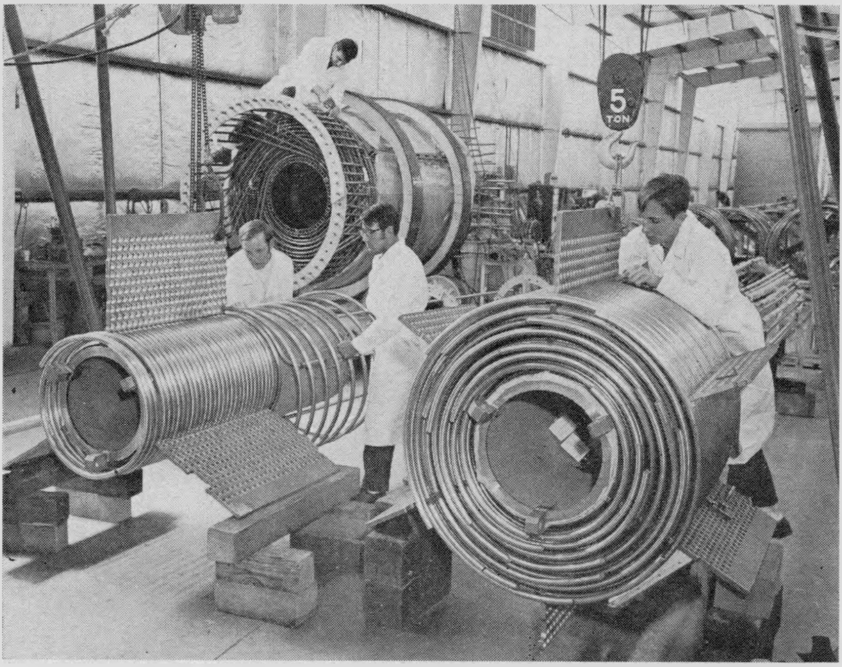
Peach Bottom first became operable on March 3, 1966, and went into commercial operation June 1, 1967.

Fort St. Vrain Reactor

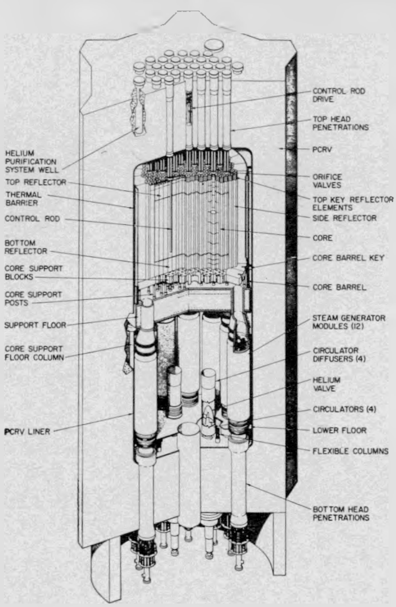
The Public Service Co. of Colorado (the owner utility), Gulf General Atomic (the designer and builder), and the AEC, agreed in April 1968 to continue with the Fort St. Vrain Nuclear Generating Station, a 330-Mwe. gas-cooled plant at Platteville, Colo., through the construction phase of the project. Site work was started in the spring and construction work, principally on the prestressed concrete reactor vessel, was started in September following issuance of a construction permit. At year's end construction was 10 percent complete.

Ultra-High Temperature Reactor Experiment

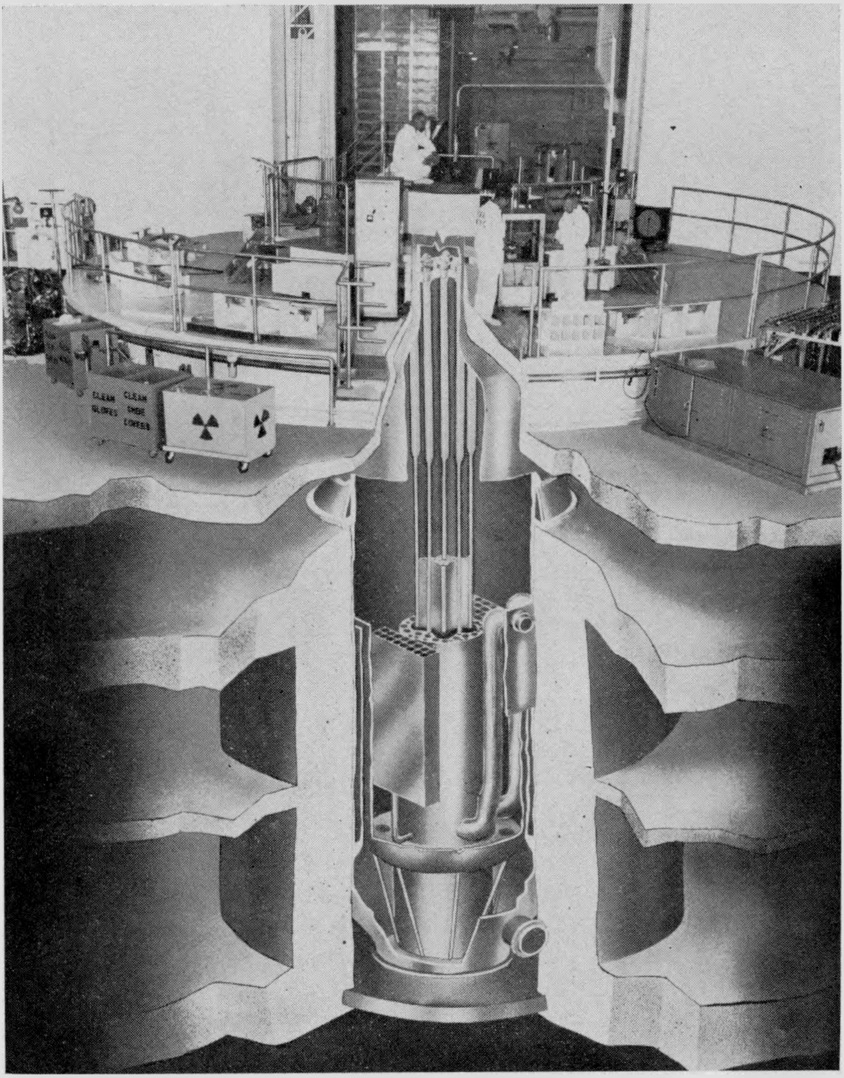
The Ultra-High Temperature Reactor Experiment (UHTREX), Los Alamos Scientific Laboratory has undergone a comprehensive series of reactor physics tests and equipment tests. Tests aimed at an approach to full power and temperature were initiated in mid-September. UHTREX is a 3-Mwe. helium (gas)-cooled graphite moderated reactor which will be used as a test facility to irradiate the type



Three Economizer/Evaporator Sections of the 12 steam generator modules to be used, for 330-Mwe. Fort St. Vrain Nuclear Generating Station are shown in various stages of fabrication. Each module contains more than 2½ miles of steel alloy tubing. The plant, under construction near Denver for Public Service Company of Colorado, will have a prestressed concrete reactor vessel to house nuclear steam supply system, including graphite moderated helium-cooled reactor, coolant circulators and steam generators. Components of the reactor are shown in drawing at *left*. Gulf General Atomic Inc. of San Diego, Calif., is prime contractor for the Fort St. Vrain project, which is being built under the AEC's Power Reactor Demonstration Program.



REACTOR ARRANGEMENT



The Advanced Test Reactor (ATR) at the National Reactor Testing Station achieved initial criticality in July 1967 and initial test operations up to 5 megawatts, thermal (Mwt.) were completed in February 1968. Testing to determine the ATR's design conditions of 250 Mwt. was initiated in December. Full power tests are scheduled for 1969. The ATR shown here in a photo-cutaway drawing, is to be used for testing fuels and materials in a high neutron intensity environment (up to 2.5×10^{15} neutrons per square centimeter per second) has nine independently adjustable testing zones for selecting a specific irradiation level for the materials to be tested. The Idaho Nuclear Corp. operates the ATR for the AEC.

of fuel proposed for use in the High Temperature Gas-Cooled Reactor program. Some fission products are expected to be released from the fuel and contained within the UHTREX system, so information will be obtained on fission product release to the helium coolant, and on the transport and deposition of fission products within the system and on system maintenance problems. The circulating helium is continuously purified, and fission products are removed and stored for later safe disposal. UHTREX does not have to be shut down for refueling; the loading face can be rotated to allow the fuel to be added to the core while the reactor is in operation.

PROJECT ADJUSTMENTS AND TERMINATIONS

Technical difficulties required adjustments of project plans or the termination of projects which had fulfilled their roles in the development program.

BONUS Reactor

In July 1968, the AEC and the Puerto Rico Water Resources Authority (PRWRA) announced agreement to terminate operation of the Boiling Nuclear Superheat Power Station (BONUS) located at Punta Higuera, P.R.

BONUS was a joint project of the AEC and PRWRA under the AEC's cooperative civilian Power Reactor Demonstration Program. The project was initiated in 1960. The plant began operation in 1964 and provided technology concerning nuclear superheating. Over 250,000,000 kilowatt hours of thermal energy were produced during the plant's operation. However, there were continuing technical problems, such as superheater fuel leaks, control rod drive malfunctions, preheater-dryer piping cracks, core flow reductions caused by corrosion-product deposits, and cracked boron-stainless steel control rods.

In addition to the technical problems, a major factor in the decision to terminate was the AEC's decreased interest in superheat reactors.

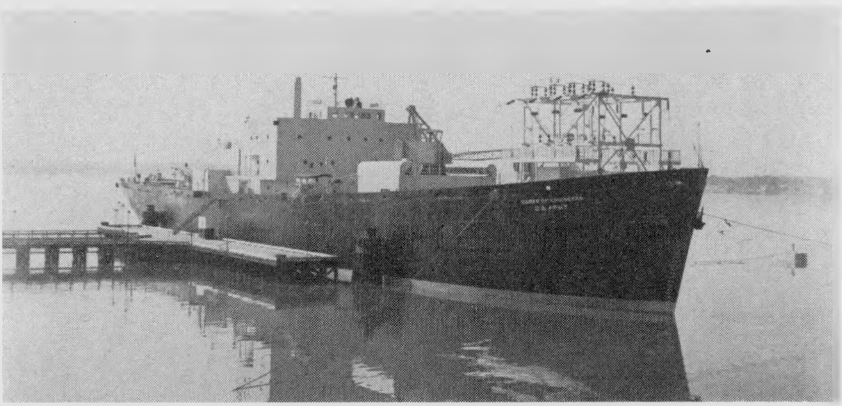
AEC and PRWRA, when announcing the decision to terminate plant operations, also announced their intention of conducting studies relating to the use of nuclear energy, in Puerto Rico, for producing electricity, desalting seawater, and other purposes. Present plans call for the preparation of BONUS as an exhibit center where visitors can gain firsthand knowledge of a nuclear powerplant.

Pathfinder

The Northern States Power Co. announced plans in September 1968 to install gas-fired boilers at the Pathfinder Atomic Power Plant in Sioux Falls, S. Dak. After a plant shutdown in September 1967, cracked and broken internal equipment in the steam system was discovered. Installation of the boilers would permit use of the turbine generator for generation of electricity even though the nuclear steam supply system is not in operation.

DESALTING AND PROCESSING USES

In addition to the generation of electricity, nuclear powerplant steam can be used for industrial processes and for desalting sea water, and the AEC has been examining nuclear systems which can be used for such dual purposes. The AEC's nuclear desalting efforts have been closely coordinated with the programs of the U.S. Department of the Interior's Office of Saline Water (OSW).



Prepared to Supply Emergency Power on short notice, the U.S. Army's AEC-developed floating 10 Mwe. nuclear powerplant *Sturgis* was moved to the Panama Canal in July 1968 when a critical shortage of electricity occurred at the Gatun Locks. Photo shows the *Sturgis* while it was moored on the Potomac River during its break-in period at Fort Belvoir, Va., after the AEC turned it over to the Army in 1967. An old Liberty ship was stripped of its normal propulsion and other equipment and a Martin-Marietta Corp. light-water reactor installed to create a floating powerplant that can be towed anywhere in the world.

Bolsa Island Project

One of the most promising planned projects for early large demonstration of the production of desalted water with the generation of electricity had been the Bolsa Island Power and Desalting Project.

The original plan was for construction of a manmade island off the southern California shore with two nuclear reactors capable of generating 1,800 Mwe. and a desalting plant ultimately capable of producing 150 million gallons a day of fresh water. Participants included the AEC, the U.S. Department of the Interior, the Metropolitan Water District of Southern California, Los Angeles Department of Water and Power, Southern California Edison Co., and the San Diego Gas & Electric Co.

In July, it was announced that the project as planned for construction near Huntington Beach, Calif., was determined not to be economic for all participants based on a revised estimated cost of $765 million. The participants, reiterating their continuing interest in the future of nuclear dual-purpose plants for California and the concept of island siting for such plants, agreed to explore means by which the project could be constructed on a more economical basis.

On the basis of investigations of alternative arrangements and sites, the management board for the project recommended that the participants proceed now with a 50 million gallon a day plant coupled with a nuclear powerplant which the two electric utility companies would build on their existing San Onofre site on the Camp Pendleton Marine Reservation. Contemporaneously with this effort, the participants would also work cooperatively to advance their ability to use either a new easement at Camp Pendleton or the original Bolsa Island site for a second phase project. However, the Board of Directors of the Metropolitan Water District (MWD) decided in December to adhere to the Bolsa Island site on a delayed schedule for the project providing an operational plant no later than 1980 rather than to proceed now at an alternative site. Discussions are continuing to determine whether project arrangements can be developed which meet the objectives of the Government's large-scale nuclear desalting program and which will be acceptable to MWD and the participating electric utilities.

Agricultural-Industrial Complexes

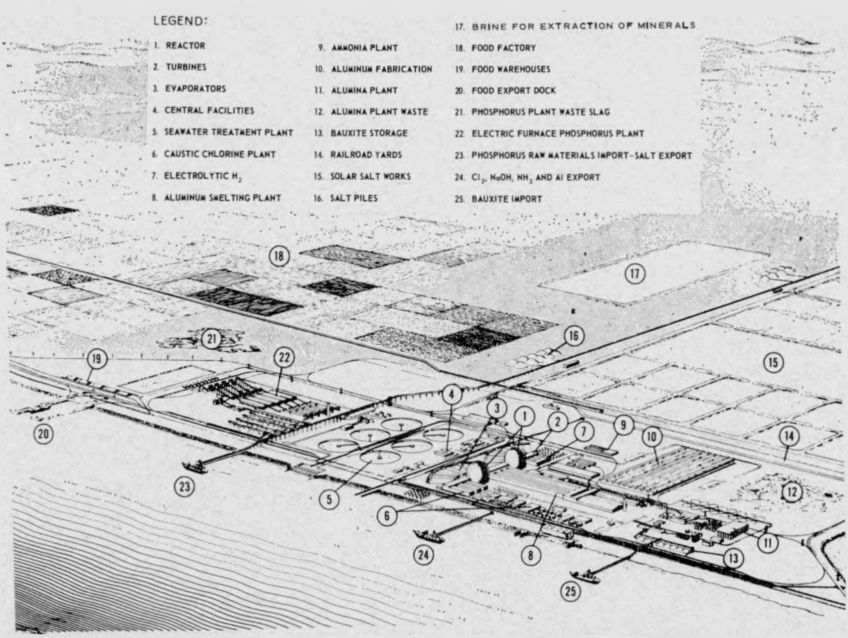
A preliminary technical and economic study [5] by the Oak Ridge National Laboratory (ORNL) was completed in August 1968 on large

[5] "ORNL–4290, Nuclear Energy Centers, Industrial and Agro-Industrial Complexes," and the summary "ORNL–4291. Nuclear Energy Centers, Industrial and Agro-Industrial Complexes, Summary Report"; available from Clearinghouse for Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va. 22151, for $3.00 each.

nuclear energy centers providing power for industrial and agro-industrial complexes. The study concluded that such energy centers have potential for upgrading the economies of arid coastal regions of the world.

A typical industrial complex could include interrelated processes for the production of fertilizers, aluminum, phosphorus, caustic soda, chlorine, and ammonia. Agro-industrial complexes would be located on the seacoast with large-scale desalting of sea water to support highly intensive irrigated agriculture on a year around growing basis if climate permitted. The study indicated that the energy center concept might have application in several areas of the world.

The study results are proving useful in a subsequent specific study of the potential of nuclear-powered agro-industrial complexes in the Middle East which was initiated by ORNL in 1968. The results are also being used by ORNL to provide technical assistance to an Indian study group examining the application of nuclear desalting at various locations in India.



A Large Nuclear-Powered Agro-Industrial Complex which could produce up to 1 billion gallons of fresh water from the sea per day and more than 2,000 megawatts of electricity. Powered by twin 1,100-megawatt nuclear reactors, the complex could feed 6 million persons from a scientifically managed 300,000-acre "food factory." Fertilizers (ammonia and phosphorous), aluminum and chlorine could be produced by satellite industrial plants. The applicability of such complexes for the Middle East and Puerto Rico is the subject of AEC studies underway at Oak Ridge National Laboratory.

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Dual-Purpose Nuclear Plants for New York City

During 1968, a study was initiated to assess the potential of dual-purpose nuclear plants to provide power and water for the New York City area. Participants in the study are the AEC, OSW, New York State, New York City, and the Consolidated Edison Co. of New York, Inc.

Puerto Rico Study

A study of the energy center concept for Puerto Rico was initiated by the AEC and the Department of Interior, in conjunction with the Commonwealth of Puerto Rico, to aid in planning for the development of the coastal regions of Puerto Rico.

International Interest

International interest in dual-purpose nuclear power desalting plants remained strong during 1968, and the International Atomic Energy Agency continued to play an important role in fostering and monitoring cooperative nuclear desalting efforts. The AEC participated in an International Nuclear Desalting Symposium in Madrid, in November 1968, sponsored by the IAEA.

A United States-Mexico-IAEA nuclear desalting study group completed evaluation of the technical and economic feasibility of installing very large nuclear power-desalting plants near the Gulf of California in Mexico to produce fresh water and electric power for the arid regions of Arizona and California and the Mexican States of Baja California and Sonora. The study concluded that large dual-purpose nuclear plants are technically feasible for providing needed fresh water and power and that the economic forecast for such plants was sufficiently attractive to merit further consideration.

SUPPLEMENTAL RESEARCH REPORT

AEC-sponsored basic research and exploratory developments are described in the AEC's "Fundamental Nuclear Energy Research—1968" report [6] which supplements this "Annual Report to Congress for 1968." Some of the more noteworthy advances in nuclear reactor technology described in somewhat greater detail in the fundamental research report are presented below as program "highlights."

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[6] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $4.25.

REACTOR TECHNOLOGY PROGRAMS

The leading section (pt. 1) of the supplemental report covers the AEC's nuclear reactor safety program, as well as advances made in reactor technology, fuels development, heat-transfer, and reactor instrumentation. Among the notable accomplishments are:

Nuclear Safety Research

• Evaluations are being made on material properties, fracture characteristics, irradiation effects, and nondestructive testing techniques of heavy section steels (12-inch or greater) proposed for future water reactor pressure vessels.

• An acoustic emission technique for detection and location of incipient failures in reactor vessels and piping systems under operating conditions is in use and has been determined to be feasible.

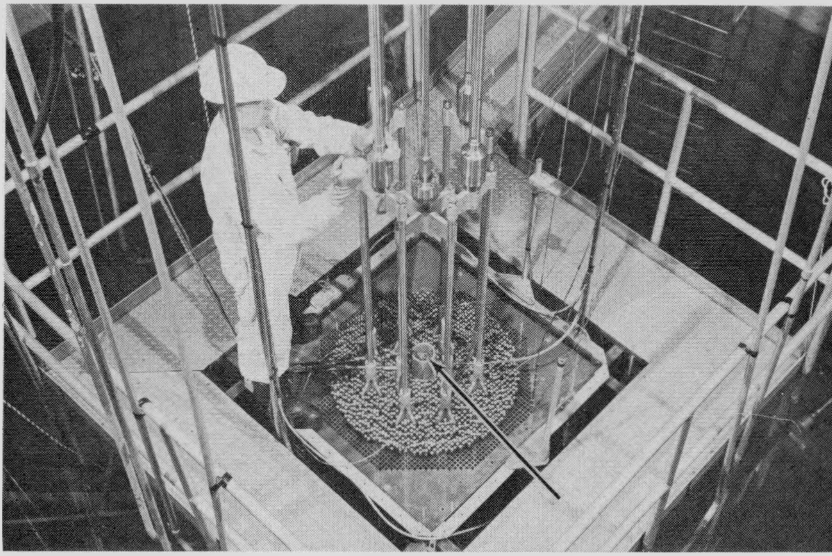
Management of Radioactive Wastes

• A review of waste management operating experience of six commercial nuclear plants in the United States, from the standpoint of releases of radioactive material to the environment, showed that discharges of both gases and liquid waste have been well below the established radiation protection guidelines. It showed, also, that these limits have not been exceeded during operation, even on the few occasions when equipment failed or where fuel elements were found to be defective.

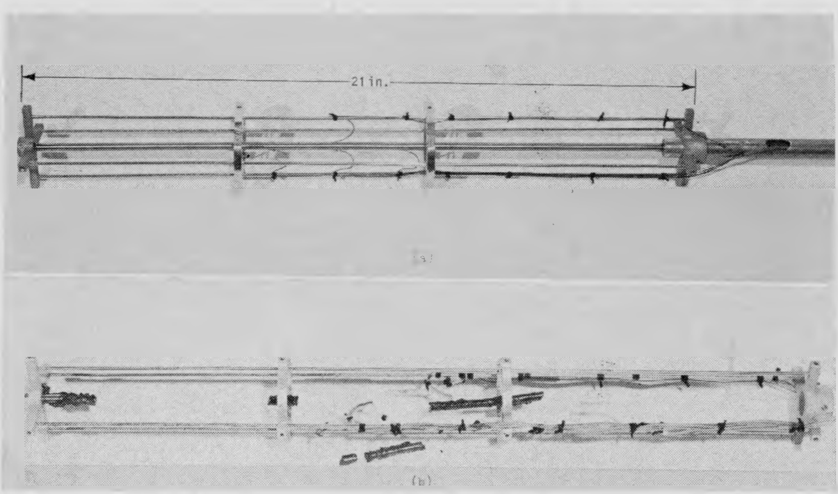
• A computer model is being developed to predict water quality in any river system under various combinations of man-made or natural circumstances. The model developed for use on the Columbia River has been applied successfully to the Deerfield River (Mass.) and the Illinois River, and efforts are being made to apply it to the upper Mississippi and Ohio River basins.

• The first complete system for the permanent disposal of intermediate level radioactive waste has been demonstrated by disposal of 461,000 gallons of contaminated waste containing about 235,000 curies of activity.

• Successful demonstration of the conversion of high-level radioactive waste from a liquid to an immobile solid form has been accomplished using the pot calcination, phosphate glass, and spray solidification processes. Over 5.5 million curies of waste, equivalent to that from nearly 20 tons of nuclear power fuel, have thus far been solidified.

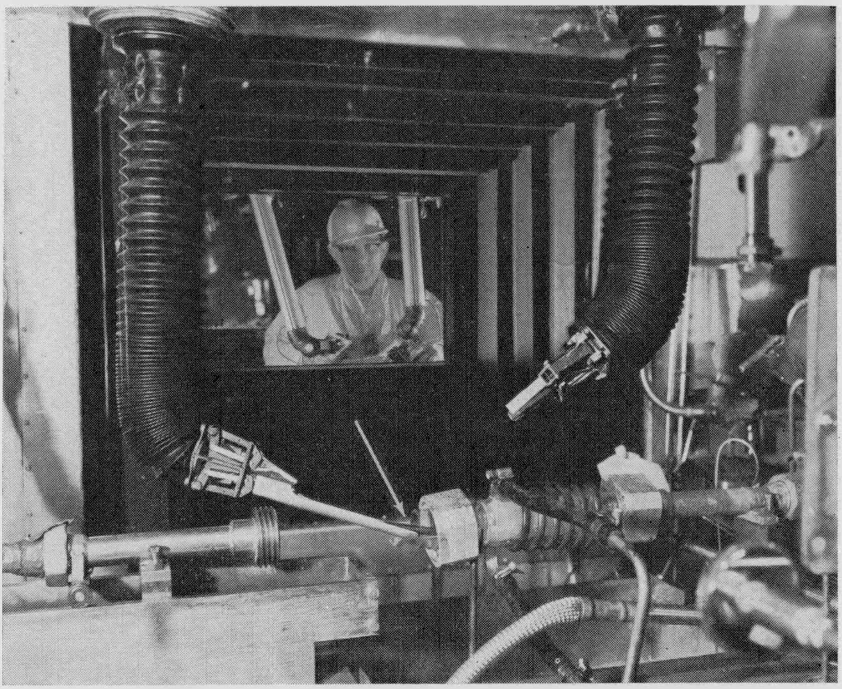


The Capsule Driver Core (CDC), installed in the SPERT–IV reactor at the National Reactor Testing Station, produces high-energy power pulses for testing fuel samples. The samples are irradiated in a central test space (see *arrow* in photo *above*) under controlled conditions. These include heating rates, power distributions, and radiation levels typical of those postulated for reactor accidents. The tests are providing experimental data on potential accident phenomena for large commercial power reactors. Shown *below* are "before" (*a*) and "after" (*b*) views of a zirconium-clad, uranium oxide fuel rod tested in the CDC to determine the physical consequences of fuel element failure and the thresholds and causes of the failure. An intense power burst resulted in complete melting and partial vaporization of the fuel rod. In addition to pressure and temperature measurements, the metal-water reaction was determined for calculating the total energy that would be generated for similar reactivity "accidents." The Capsule Driver Core is operated for the AEC by Phillips Petroleum Co.



Nuclear Fuels and Materials

- A simplified method of producing test reactor fuel plates directly at the fuel reprocessing plant has been developed. It eliminates the necessity for shipment of radioactive material to a refining plant, as well as metal refining steps, saving both cost and time.
- A technique for obtaining extremely small samples of irradiated fuels by laser beam vaporization has been developed and makes it possible to obtain much new information on behavior of fuels at various stages during irradiation because of the ease of obtaining specimens and because the specimens can be located precisely.



A Highly Irradiated Miniature Fuel Pin (indicated by *arrow*), 6 hours removed from the Materials Testing Reactor at the National Reactor Testing Station in Idaho, is shown being loaded remotely into an induction-heated quartz melting furnace in the Contamination-Decontamination Experiment (CDE). Melting of the fuel pin in a stream of pressurized steam produces a fission product aerosol under the conditions of a loss-of-coolant accident. The radioactive aerosol is used to study the transport and deposition of fission products in containment systems, to evaluate surface coatings and decontamination procedures, and to test sampling devices and radiochemical analytical methods. The research is being performed to support the Loss of Fluid Test (LOFT) reactor safety experiments scheduled for the NRTS early in the 1970's. The CDE facility is operated for the AEC by Idaho Nuclear Corp.

Materials Development

- A nondestructive inservice inspection technique based on acoustic emission to detect potential failure of reactor components has been developed; and a new eddy current technique to detect cracking in nuclear rocket reactor components is being used. Both of these processes permit detection, location, and size determination of specific faulty areas.

Reactor Physics Research

- Experiments have been performed on a series of three low-power, room-temperature, critical experiment facilities (Zero Power Reactors), to point up problem areas in the design of large plutonium-fueled fast reactors. Comprehensive data were obtained on generalized cores having compositions similar to these expected in the plutonium-fueled, sodium cooled fast power reactors.
- Lattice experiments are providing new measurements of one of the more vital quantities determining the rate of breeding of plutonium in fast breeder reactors. This quantity is the value of the relative susceptibility of plutonium-239 to two possible effects (capture of neutrons to produce plutonium-240, and fission) induced by the neutron spectra typical of breeder reactors.

Heat Transfer and Fluid Dynamics

- Experiments performed with electrically heated tubular test sections to investigate the influence of coolant flow rate, pressure, and heat content, on the upstream boiling burnout heat flux of a liquid-cooled nuclear reactor have shown results contradictory to accepted theory.
- Studies on the phenomenon of incipient-boiling superheating of alkali liquid-metals used in fast breeder reactors have, for the first time, shown it is possible to determine the functional dependence of incipient boiling superheats on each of three independent variables: deactivation pressure, deactivation temperature, and boiling pressure.
- Results of experiments to understand the problems associated with asymmetry heat transfer effects in liquid-metal-cooled nuclear power reactors show the importance of maintaining geometrical symmetry in rod bundles and tube banks which are cooled by inline flow of a liquid-metal coolant.
- Theoretical and experimental research conducted to determine the heat transfer characteristics of a gas which is flowing, in the plasma

state, in a water-cooled channel indicates that conventional heat transfer design correlations can be modified satisfactorily to predict the behavior of an intensely radiating gas stream.

Reactor and Process Instrumentation

- New temperature-measuring techniques and instruments which use ultrasonic waves have been developed for accurate measurement of high temperatures by exploiting the relationship between sound velocity and temperature in materials.
- An acoustic detector has been developed which can "hear" the collapse of tiny bubbles that form on hot fuel surfaces as soon as the coolant begins to boil, thus permitting reduction of power or shutdown to halt undesirable boiling of the coolant.
- A high resolution neutron radiography system has been developed which provides neutron radiographs with details comparable to that obtainable with conventional X-ray techniques. This system extends or complements information gained by using X- or gamma rays in some cases and, in other instances, provides the only means of inspection.

Chapter 6

LICENSING AND REGULATING THE ATOM

THE REGULATORY PROGRAM

The trend toward large-scale civilian nuclear powerplants continued to play a prominent role in the AEC's regulatory activities in 1968. During this, its most active year of licensing and regulation, the AEC authorized construction of 23 nuclear power reactors with a combined design capacity of more than 18,000 Mwe. (megawatts of electricity), representing an initial capital investment by utilities exceeding $3 billion.[1] By year's end, 44 nuclear power units were under construction in 19 States, nearly all of which were scheduled to begin commercial operation over the next 5 years.

The AEC continued to seek improvement in its licensing procedures to accommodate expanding uses of atomic energy and, at the same time, strengthened its program for protecting public health and safety against the effects of radiation and for safeguarding the common defense and security. A new study group undertook a review of the regulatory program for nuclear facilities in the wake of several earlier studies to assure that licensing procedures keep pace with the rapid expansion in the nuclear industry. Progress was made in establishing additional safety criteria and standards for reactors, highlighted by actions to assure quality in design and fabrication of reactor systems and components. Development of basic criteria for design and siting of reactors in earthquake zones reached an advanced stage. In the licensing of atomic energy materials, several actions were taken to simplify licensing procedures, particularly those authorizing the use of radioisotopes. As the AEC continued to strengthen its program for safeguarding special nuclear material from the standpoint of the common defense and security, three district offices, under the Director of Regulation, were established to conduct safeguards inspections of such

[1] Based on initial cost estimates in applications for nuclear powerplant construction permits.

materials in the possession of licensees (see Ch. 2—"Nuclear Materials Safeguards").

A schedule of fees to be charged for AEC licenses was established in October.

AEC licensees as a whole continued to compile a good radiation safety record as reflected by results of inspections by AEC compliance personnel, a survey of the atomic energy industry by the Bureau of Labor Statistics, and records of film badge exposures from major film badge processors.

Two more States—Colorado and Idaho—entered into agreements with the AEC in 1968 for the assumption of certain regulatory authority over atomic energy materials, bringing to 19 the number of participating Agreement States.

MAJOR FACILITY LICENSING

As the volume of construction permit applications tapered off from the 1967 peak, attention was focused on the safety aspects of quality in design, fabrication, and construction of the large number of nuclear powerplants underway; preoperational testing; and the preliminary operating experience of large power reactors recently completed.

Quality Assurance During Construction

Problems encountered by reactor manufacturers and utilities in constructing the "new generation" of power reactors, and in the fabrication of reactor components, resulted in increased emphasis on quality control and assurance. The AEC made a major effort to assure that an adequate quality assurance program was in effect at each nuclear facility under construction. Inspections of these reactors were increased by nearly 50 percent over the inspection frequency of 1967.[2] Specialized skills, especially in the field of metallurgy, were used to a greater degree in AEC inspections.

Substantial progress was made in a coordinated AEC-industry program to upgrade existing safety standards and codes for reactors and to develop additional safety standards in new areas where required. The industry code for nuclear power piping was published for trial use. In cooperation with the AEC, professional societies also neared completion of a code for in-service inspection of reactor coolant system components which are critical to safety. Work was begun on a code which is intended to assure that nuclear powerplants are constructed

[2] Inspection frequency for power reactors under construction rose from an average of 3.4 a year per reactor in 1967 to about 5 per year in 1968.

in accordance with agreed-upon design requirements. (See later item on "Reactor Criteria and Standards.")

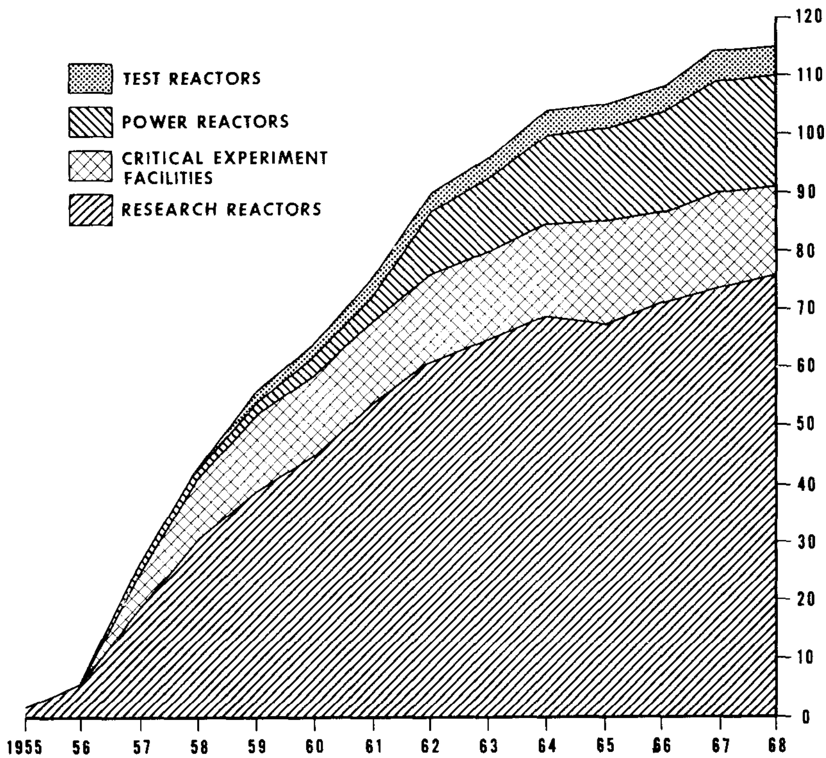
Licensed Reactors in Operation

At year's end, the AEC had licensed the operation of a total of 109 nuclear reactors of all types (power, research, and test), including 15 for the generation of electric power, since the beginning of the regulatory program in 1954. These 109 units of all types had accumulated a total of about 760 reactor-years of operation without a radiation fatality or serious radiation exposure. Within this total, power reactors as a group compiled a record of about 86 reactor-years of operating experience.

GROWTH OF LICENSED NUCLEAR REACTORS AND FACILITIES

DECEMBER 31, 1955 - DECEMBER 31, 1968

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



To verify the adequacy of present AEC regulations governing routine releases of radioactivity from nuclear facilities, the AEC has begun a limited program of environmental monitoring in the vicinity of several licensed operations. Monitoring programs are being developed for a boiling water reactor, a pressurized water reactor, an irradiated fuel reprocessing plant, a fuel fabrication plant, and a large-scale processor of radioisotopes. The AEC also is cooperating with the U.S. Public Health Service and the States in an information exchange program on results of environmental samples taken independently by the various agencies. The new monitoring program supplements the AEC's regular practice of reviewing records of licensees' environmental sampling programs. These have indicated that releases of radioactivity from the sites of nuclear facilities have thus far remained well within AEC requirements.[3]

Status of Licensed Civilian Nuclear Power

At the end of 1968, central station nuclear powerplants in operation, under construction, or for which applications were under review by the AEC represented a total of about 50,000 net Mwe., as follows:

Thirteen operational, with an installed capacity of 2,724 net Mwe.[4]

Forty-four under construction, with a total initial capacity of about 33,000 net Mwe.

Sixteen under review for construction authorization, with a combined design capacity of 14,230 net Mwe. In addition, utilities had placed orders for 17 units totaling approximately 15,000 net Mwe., for which construction applications had not been received by the AEC at year's end. (The application for the Malibu Nuclear Plant in California is inactive and is not included in the 16 under review.)

CONSTRUCTION PERMITS ISSUED

The AEC completed 18 initial licensing proceedings in 1968 and issued permits for the construction of 23 power reactors (see table 1). The total initial design capacity of the plants authorized during 1968 was 18,324 Mwe., nearly seven times the installed capacity of all

[3] See p. 40 of supplemental "Fundamental Nuclear Energy Research—1968" report.

[4] Includes the Shippingport Atomic Power Station, Pa., which was initiated as a cooperative project of the AEC and Duquesne Light Co. and the AEC's "N" reactor at Hanford, Wash., which produces steam for the Washington Public Power Supply System's 790-Mwe. generating station. Does not include the Hallam (Nebr.) Nuclear Power Facility, which is being dismantled; the Carolinas-Virginia Tube Reactor, Parr, S.C., for which the operating license has been terminated; Northern States Power Co.'s Pathfinder Plant, which is shut down; and the Piqua Nuclear Power Facility, Ohio, and the Puerto Rico Water Resources Authority's BONUS reactor, both of which have been shut down and operational arrangements terminated.

nuclear powerplants which were operable on December 31, 1968. Eight of the newly approved reactors will produce in excess of 1,000 Mwe. each, and 10 are to be installed in five twin-reactor central power stations.

Among the nuclear plants approved during the year, the 330-Mwe. Fort St. Vrain Nuclear Generating Station, being built about 35 miles north of Denver, is the only one that involves AEC funding. The high-temperature gas-cooled reactor, a project of the Public Service Co. of Colorado, is being built under the AEC's Power Reactor Demonstration Program.[5]

TABLE 1.—CONSTRUCTION PERMITS ISSUED—1968

Applicant	Plant	Month	Unit size (net Mwe.)	Projected operation
Philadelphia Electric Co. (Pa.)	Peach Bottom-2	January	1,065	1971
	Peach Bottom-3	January	1,065	1973
Pacific. Gas & Electric Co. (Calif.)	Diablo Canyon-1	April	1,060	1971
Metropolitan Edison Co. (Pa.)	Three Mile Island	May	831	1971
Consumers Public Power Dist. (Nebr.)	Cooper Station	June	778	1972
Omaha Public Power Dist. (Nebr.)	Ft. Calhoun	June	457	1971
Virginia Electric & Power Co	Surry Station-1	June	783	1971
	Surry Station-2	June	783	1971
Northern States Power Co. (Minn.)	Prairie Island-1	June	530	1972
	Prairie Island-2	June	530	1974
Wisconsin Electric Power Co. and Wisconsin-Michigan Power Co.	Point Beach-2	July	455	1971
Tennessee Valley Authority (Ala.)	Browns Ferry-3	July	1,065	1972
Wisconsin Public Service Corp	Kewaunee	August	527	1972
Boston Edison Co. (Mass.)	Pilgrim Station	August	625	1971
Public Service Co. of Colorado	Fort St. Vrain	September	330	1972
Public Service Electric & Gas Co. (N.J.)	Salem-1	September	1,050	1971
	Salem-2	September	1,050	1973
Florida Power Corp	Crystal River-3	September	825	1972
Sacramento Municipal Utility District (Calif.)	Rancho Seco	October	800	1973
Maine Yankee Atomic Power Co	Maine Yankee	October	790	1972
Arkansas Power & Light Co	Russellville	December	825	1972
Commonwealth Edison Co. (Ill.)	Zion-1	December	1,050	1972
	Zion-2	December	1,050	1973

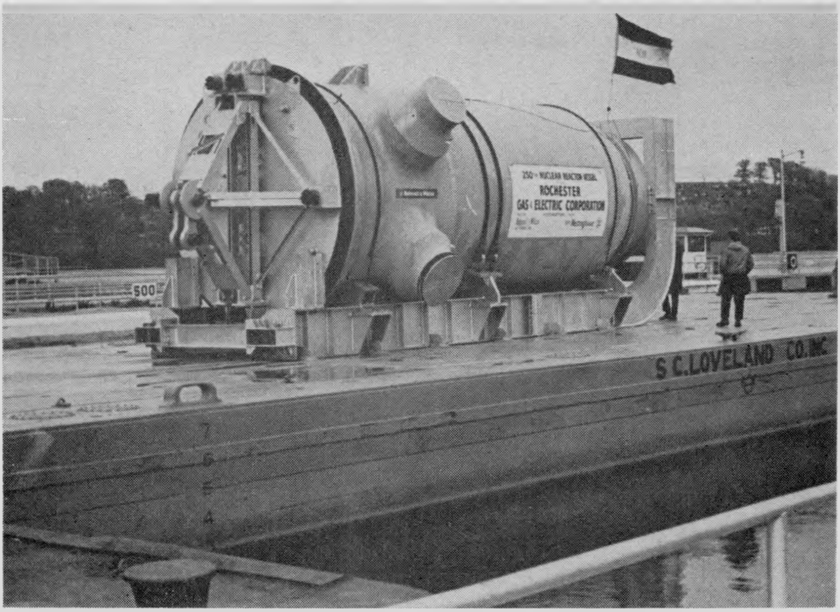
NEW CONSTRUCTION APPLICATIONS

Although the volume of nuclear powerplant construction applications fell below the 1967 peak when electric utilities filed for 29 reactors, the rate of requests for construction permits was high in 1968, approaching that of 1966. During the year, 10 utilities requested authority to build 13 nuclear power reactors (see table 2). The trend toward multiunit nuclear stations continued.

[5] Projects in which industry and the AEC share costs; the PRDP assistance is no longer provided for light-water reactors.

TABLE 2.—NUCLEAR POWERPLANT CONSTRUCTION APPLICATIONS RECEIVED—1968

Applicant	Plant	Month	Unit size (net Mwe.)	Projected operation
Baltimore Gas & Electric Co. (Md.)	Calvert Cliffs-1	January	800	1972
	Calvert Cliffs-2	January	800	1973
New York State Electric & Gas Co	Bell Station	March	838	1973
Jersey Central Power & Light Co. (N.J.)	Oyster Creek-2	April	810	1973
Georgia Power Co	Edwin I. Hatch	May	786	1973
Long Island Lighting Co. (N.Y.)	Shoreham Station	May	523	1973
Pacific Gas & Electric Co. (Calif.)	Diablo Canyon-2	July	1,070	1974
Carolina Power & Light Co. (N.C.)	Brunswick-2	July	821	1973
	Brunswick-1	July	821	1974
Tennessee Valley Authority (Tenn.)	Sequoyah 1	October	1,129	1973
	Sequoyah 2	October	1,129	1974
Iowa Electric Light & Power Co	Duane Arnold	November	538	1973
Power Authority of the State of New York	John A. FitzPatrick	December	815	1973



Giant Nuclear Reactor Vessel fabricated by Babcock & Wilcox for Westinghouse Electric Corp. is shown here on route to Rochester Gas & Electric Corp., Brookwood powerplant at Ontario, N.Y. The 250-ton vessel was shipped via the inland waterway system and the Great Lakes. It was the first nuclear reactor to be shipped from B. & W.'s Mt. Vernon, Ind., facility, which is located on the Ohio River.

Application Withdrawals

Proposals for construction of four power reactors, filed in 1967, were withdrawn or postponed during 1968 and one application was amended for a change of site.

Easton Station. The Niagara Mohawk Power Corp., on August 20, withdrew its application for authority to construct its projected Easton (N.Y.) Nuclear Station because of difficulties in obtaining site approvals from other governmental bodies dealing with matters not related to radiation safety. Located on the east side of the Hudson River in Washington County, N.Y.—across from the Saratoga National Historical Park—the Easton site was the first proposed for a nuclear reactor to receive adverse comments from the Advisory Council on Historic Preservation, a statutory body charged with commenting on undertakings that have an effect on cultural property listed in the *Registry of National Historic Landmarks*.[6] Niagara Mohawk's application for the 766-Mwe. boiling water reactor had been under AEC review since August 1967 and the unit was scheduled for commercial

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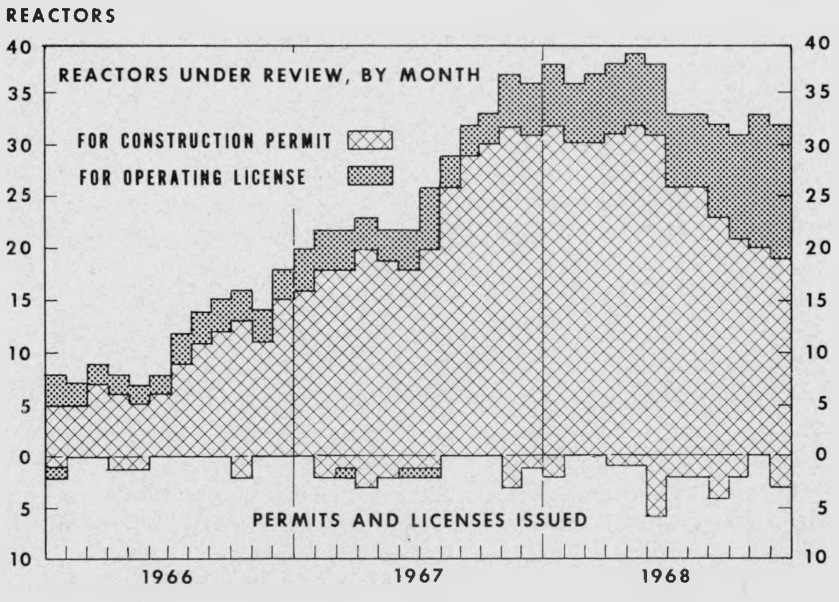
[6] The Advisory Council on Historic Preservation was established by section 106, Title I of Public Law 89–665, "National Historic Preservation Act," which became effective Oct. 15, 1966. The *Registry of National Historic Landmarks* is maintained by the National Park Service.

NUCLEAR POWER REACTOR APPLICATIONS AND APPROVALS, 1966-1968
(TOTAL NUMBER OF UNITS)



operation in 1970. The utility announced that its contracts with the General Electric Co. were being transferred to the Power Authority of the State of New York, which has announced plans to construct a nuclear plant on the site of Niagara Mohawk's Nine Mile Point Nuclear Station on Lake Ontario, near Oswego, N.Y.

Bolsa Island. In July, participants postponed the proposed Bolsa Island dual nuclear power and desalting plant project as originally conceived when it was found not to be economic for all parties. The municipal and investor-owned utilities and the Federal agencies involved began explorations to reconstitute the project on a more viable basis. Applications for two 900-Mwe. nuclear power reactors involved in the project—which were to be built on a proposed artificial island off the southern California coast—had been filed in September 1967 by the Los Angeles Department of Water & Power, and the Southern California Edison and San Diego Gas & Electric companies.

Crystal River. The Florida Power Corp. withdrew its application for Crystal River Unit No. 4 on March 25. The utility advised the AEC that its evaluation of anticipated system load growth indicated that construction of a fourth unit at Crystal River—70 miles north of Tampa—for operation in 1974 did not constitute a prudent investment in generating capacity.

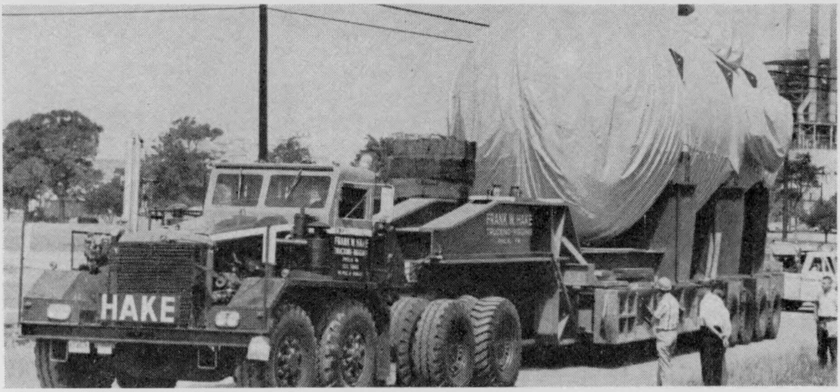
Salem, N.J., Site. The Public Service Electric & Gas Co. (N.J.), which had withdrawn its proposed Burlington site between Trenton and Philadelphia in August 1967,[7] amended its application in January to change the site to Salem County, N.J., on the Delaware River.

OPERATING LICENSES

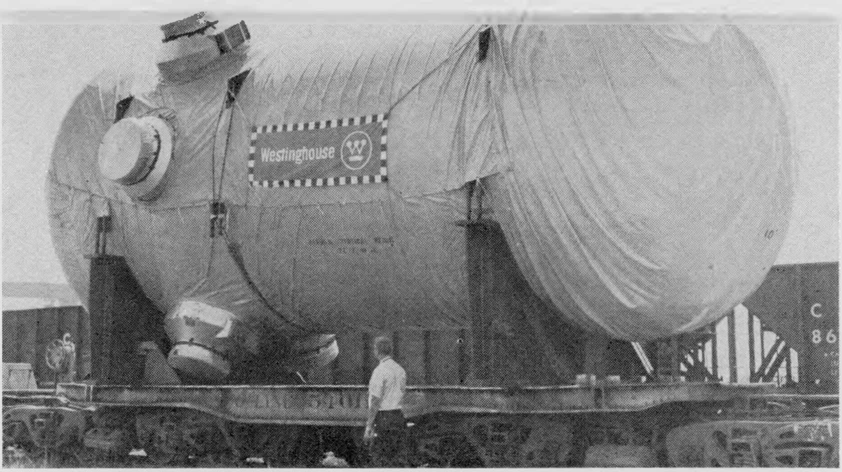
At the end of 1968, the AEC had under review operating license applications for 12 nuclear electric plants, five of which are scheduled for initial operation in 1969 (see table 3). The latter five plants, with an aggregate capacity of almost 3,000 Mwe., are: Jersey Central Power & Light Co.'s Oyster Creek Unit–1, N.J., Niagara Mohawk Power Corp.'s Nine Mile Point Nuclear Station, N.Y.; Commonwealth Edison Co.'s Dresden Station Unit–2, Ill.; the Millstone Point Co.'s Millstone Unit–1, in Conn.; and Rochester Gas & Electric Co.'s Robert Emmett Ginna Unit–1, N.Y.

In November, the AEC published a notice of intent to issue a provisional license to the General Electric Co. for operation of the unique Southwest Experimental Fast Oxide Reactor (SEFOR) near Fayetteville, Ark. Operation is expected to begin in early 1969. The 20-thermal-megawatt (Mwt.), nonelectric experimental reactor will be used to

[7] See p. 123, "Annual Report to Congress for 1967."



The Pressure Vessel for the H. B. Robinson Plant made a 2,800-mile detour to reach its final destination. In order to reach its destination at an inland site only 300 air miles from Combustion Engineering's fabrication facility at Chattanooga, Tenn., the 321-ton pressure vessel for the Carolina Power and Light Co.'s H. B. Robinson Unit No. 2 had to travel 3,100 miles by barge, truck, and railroad. First, it journeyed by barge down the Tennessee, Ohio, and Mississippi rivers to the Gulf of Mexico, crossed Florida on the Okeechobee Waterway, and moved up the Atlantic coast to the port of Georgetown, S.C. At Georgetown, the vessel was transferred to a huge truck (*above*) from a specially built dock. The 108-foot trailer rig, largest ever to operate on South Carolina highways, was used to move the vessel only 4,000 feet to a portable lifting tower where it was hoisted onto a reinforced railroad car (*below*). The vessel was said to be the widest load ever carried on an American railroad. Because the dimensions and weight (nearly 1 million pounds total) exceeded the Seaboard Coastline Railroad's normal operational limits, the final leg of the journey was made at 10 miles per hour in daylight hours. Trestles were strengthened, a new section of track was laid to bypass a bridge, and the eaves of three train stations were removed to accommodate the load. The vessel is part of a 700-Mwe. pressurized water reactor plant being constructed on a turnkey basis by Westinghouse Electric Corp. at a site near Hartsville, S.C.



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study characteristics of a fast breeder reactor system which employs mixed plutonium oxide-uranium oxide as fuel and sodium as a coolant. The project is jointly sponsored by the Southwest Atomic Energy Associates (a group of 17 utilities), a West German corporation, the European Atomic Energy Community (Euratom), and the AEC.

Among other licensing actions, the AEC authorized dismantling of the 11 Mwe. Piqua (Ohio) Nuclear Power Facility. The city of Piqua had discontinued operation of the reactor in 1966.

TABLE 3.—NUCLEAR POWERPLANT OPERATING APPLICATIONS UNDER REVIEW

Applicant	Planned	Date applied	Proposed power level (net Mwe.)	Planned operation
Jersey Central Power & Light Co. (N.J.)	Oyster Creek-1	January 1967	515	1969
Niagara Mohawk Power Corp. (N.Y.)	Nine Mile Point	June 1967	500	1969
Commonwealth Edison Co. (Ill.)	Dresden-2	November 1967	[1] 809	1969
	Dresden-3	November 1967	[1] 809	1970
Rochester Gas & Electric Co. (N.Y.)	R. E. Ginna-1	January 1968	420	1969
Millstone Point Co. (Conn.)	Millstone-1	March 1968	[1] 652	1969
Commonwealth Edison, Iowa-Illinois Gas	Quad-Cities-1	September 1968	715	1970
& Electric Companies (Ill.).	Quad-Cities-2	September 1968	715	1971
Consolidated Edison Co. (N.Y.)	Indian Pt.-2	October 1968	873	1970
Consumers Power Co. of Michigan	Palisades	November 1968	700	1970
Northern States Power Co. (Minn.)	Monticello	November 1968	[1] 545	1970
Carolina Power & Light Co. (S.C.)	H. B. Robinson-2	November 1968	[2] 700	1970

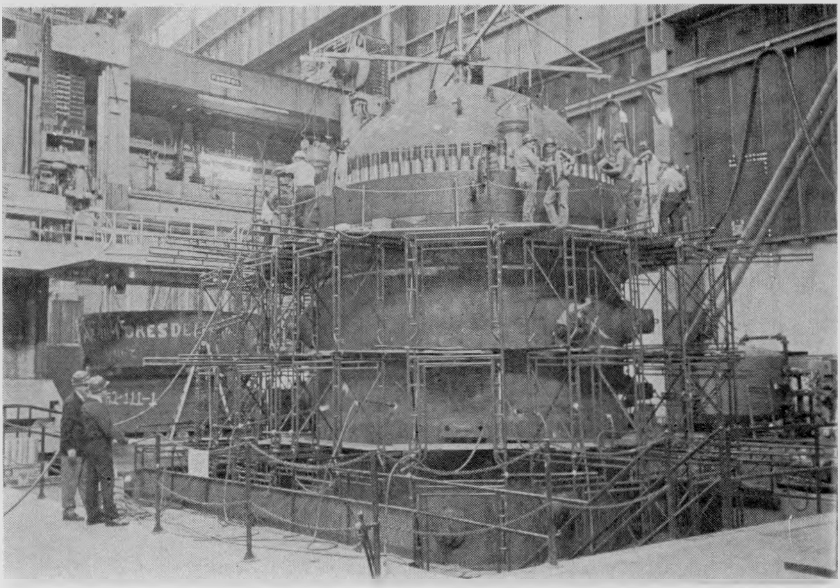
[1] Application requests authority to operate at ultimate design power level.
[2] Initial electrical capacity has been revised upward from 663 Mwe. net; ultimate design capacity is 731 Mwe. net.

Facility Operator Licensing

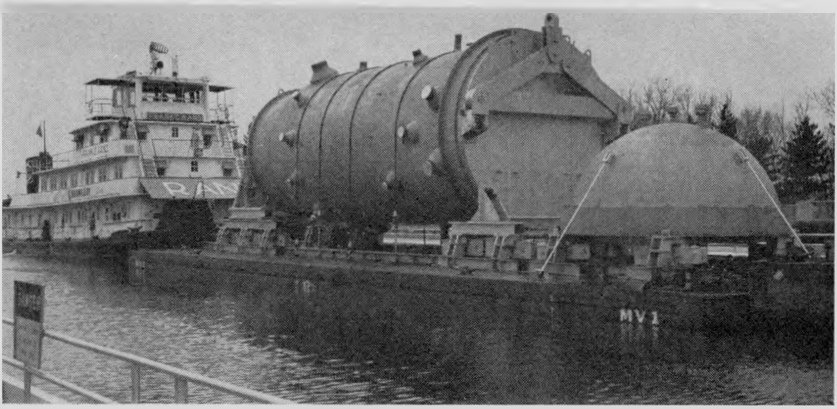
The AEC issues licenses to persons, after examination requirements are satisfied, who manipulate or supervise manipulation of controls of nuclear reactors or fuel reprocessing plants. During 1968, the AEC issued 342 operator licenses and 315 senior operator licenses. These included 330 new licenses, 15 amended licenses, and 312 renewed licenses. The total number in effect on December 31 included 1,002 operator licenses and 684 senior operator licenses.

Reactor Simulator Training

In July, the General Electric Co. opened a Nuclear Training Center at Morris, Ill., to train reactor operators for its customers. Located near the Dresden Nuclear Power Station, the center is equipped with a nuclear powerplant simulator which duplicates in detail the control room of the Dresden Unit-2 plant. AEC's licensing staff worked closely with GE and has established an interim procedure permitting use of the simulator as part of an approved training program to meet the AEC's operator licensing requirements.



The Pressure Vessel for Commonwealth Edison Co.'s Dresden Unit 2—largest vessel built to date—was shipped to the Dresden nuclear power station site near Morris, Ill., in late November. The 800-ton nuclear vessel, shown *above* in Babcock & Wilcox' Co.s fabrication shop at Mount Vernon, Ind., is approximately 72 feet long and 22 feet in diameter. The vessel and its head are shown *below* on its 740-mile barge trip from the shop via the Ohio, Mississippi, and Illinois rivers. Dresden Unit 2, a boiling water reactor powerplant scheduled for operation in 1969, will produce 809 Mwe. A similar nuclear unit, Dresden–3, is nearing completion at the same site, and is scheduled for operation in 1970. General Electric Co. is the prime contractor.



With larger nuclear powerplants scheduled for operation in growing numbers over the next several years, interest in such simulators is increasing. Other power reactor manufacturers such as Babcock & Wilcox, Combustion Engineering, and Westinghouse are planning training programs which also may include the use of simulators.

FUEL REPROCESSING PLANTS

General Electric Co. commenced construction of its Midwest Fuel Reprocessing Plant near Morris, Ill., in August under an AEC provisional construction permit issued in December 1967. Commercial operation is scheduled to begin in mid-1970. The plant is being built on a 1,300-acre site south of the Commonwealth Edison Co.'s Dresden Nuclear Power Station.

In November, Allied Chemical Corp. filed an application with the AEC for a permit to build an irradiated nuclear fuel reprocessing plant with a capacity of 5 metric tons of uranium a day. The proposed facility, to be known as the Barnwell Nuclear Fuel Plant, would be located on a 1,730-acre site which is now a part of the AEC's Savannah River Plant reservation about 7 miles from Barnwell, S.C. Plans call for transfer of the property to the County of Barnwell which, in turn, would sell or lease it to Allied Chemical.

The company has scheduled the plant for commercial operation in 1973. The application was under AEC staff review at year's end.

THE REGULATORY PROCESS

Both initial licensing and continuing surveillance of operating facilities are involved in the AEC's regulatory mission of assuring that nuclear reactors and facilities are constructed and operated in a manner consistent with public health and safety and the common defense and security. The AEC regulatory staff, in addition to regulating licensed facilities, also reviews the safety of reactors owned by the AEC and other Federal agencies and provides advice on siting, design, and operation of reactors, and on porting operations for nuclear ships.

In the initial licensing of power and test reactors and other major facilities, the construction permit application is first subject to a safety review by the AEC regulatory staff, then an independent review by the AEC's Advisory Committee on Reactor Safeguards (ACRS). Upon completion of these reviews, a public hearing on the application must be conducted by an atomic safety and licensing board (ASLB) designated by the Commission to determine whether the construction permit should be issued. The ASLB decision is subject to review by the Commissioners before becoming final. An operating license application for the completed facility is subject to the same review process, but a public hearing before an ASLB is not mandatory before the license can be issued.

Advisory Committee on Reactor Safeguards

The ACRS is a statutory committee which reviews and reports on safety studies and facility license applications referred to it by the AEC. It advises the Commission concerning the safety of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards. In addition, the ACRS assists the AEC in various other ways as requested, including participation in a continuing review of the AEC's safety research program. Increasing emphasis has been given during the past year to safety matters of a topical nature which are applicable to particular classes of reactors. This emphasis is also reflected in a continuing effort devoted to the development of safety criteria and standards.

The ACRS is a 15-man committee composed of members with extensive experience in the nuclear field and other areas of American industry, research and development laboratories, and universities. The various disciplines required for a comprehensive review of nuclear safety matters are represented on the committee. Committee members are appointed for 4-year terms by the Commission. The ACRS is organized into various subcommittees with 80 subcommittees currently established for specific projects and 20 subcommittees for topical matters and related standards, criteria and guides.

During 1968, the ACRS met on 14 occasions, and 83 meetings of subcommittees were held. The committee provided reports on 23 licensed nuclear facilities, and two reports on AEC-owned facilities. It also provided reports to the AEC on seismic research and the results of a review by an advisory task force on emergency core cooling. These reports represent 19 reviews at the construction permit stage, four reviews at the operating license stage, and two reviews of proposed changes in operating facilities. (For a list of ACRS members, see app. 2.)

Matters Outside the AEC's Jurisdiction

During 1968, attention was focused in several licensing proceedings and in Congress on matters over which the AEC has no regulatory jurisdiction under present law.

The matters of primary concern were: (*a*) the "thermal effects" of cooling water discharged from powerplants [8] on the ecology of rivers and other bodies of water; and (*b*) the efforts of smaller utilities—mostly of local government or consumer-owned (co-op) power distributing systems—to participate in ownership of generating plants planned by larger investor-owned utilities, and thus, to share in the anticipated benefit of low-cost power.

Thermal Effects

It has been urged that the AEC should consider the thermal effects of water discharged from nuclear powerplants into adjacent bodies of water and impose conditions in licenses relating to those effects. The AEC's position, concurred in by the Department of Justice, is that the AEC has no authority, under present statutes, to consider thermal effects as opposed to radiological effects in its licensing proceedings. A number of bills were introduced in the 90th Congress which would, if enacted, have given authority to the AEC or other agencies such as the Federal Power Commission, to impose conditions relating to thermal effects in nuclear powerplant licenses.

Participation in Projects by Smaller Utilities

Smaller utilities, seeking to participate in large-scale nuclear power projects, raised the issue that lack of opportunity to share in the ownership and benefits of such plants would create a situation inconsistent with the antitrust laws.

The AEC has specific statutory authority concerning prelicense consideration of antitrust matters in issuing "commercial" licenses for power reactors under section 103 of the Atomic Energy Act. However, licensing under section 103 is not permitted by the act until the Commission has made a finding of demonstrated "practical value" for a given reactor type pursuant to section 102. In the absence of sufficient actual operating experience with the larger-size reactors, the Commission has been unable to find the requisite demonstration; thus, all licenses issued through 1968 have been for developmental reactors under section 104b. of the act.

During the last session of Congress, the AEC submitted proposed legislation which would eliminate the requirement for a finding of practical value. Several legislative proposals by various sponsors at-

[8] Cooling water is circulated around the secondary (nonradioactive) loop of a powerplant to condense the steam. The cooling water receives some heat from the secondary loop and the water is discharged to the stream or other adjacent body of water. The cooling water does not come into contact with the reactor core or nuclear fuel.

tempted to resolve the issue of making anticipated low-cost electric power generated by large scale plants, including nuclear plants, available to smaller utilities.

ADJUDICATORY ACTIVITIES

In 1968, a record number of public hearings were held to consider applications for nuclear facility construction permits—the most active year since atomic safety and licensing board hearings were provided for by statute in 1962. Several proceedings were contested,[9] and a number of ASLB decisions were appealed to the Commissioners.

Atomic Safety and Licensing Boards

The office of the Atomic Safety and Licensing Board Panel [10] appointed 17 atomic safety and licensing boards (ASLB's) during the year to conduct public hearings for review of nuclear powerplant construction permits.

Each three-man board, drawn from the Atomic Safety and Licensing Board Panel (see app. 2), is composed of two technically qualified members and a chairman qualified in the conduct of administrative proceedings. The panel consists of 19 technical experts with extensive experience in industrial and academic nuclear programs and seven attorneys with wide experience in administrative proceedings.

In each case, the ASLB conducts the public hearing on the construction permit application in the vicinity of the proposed site. After considering the record of the hearing, the ASLB issues an initial decision on granting a construction permit. Before becoming final, this decision is subject to appeal by the parties in the proceeding and to review by the Commissioners.

The 17 ASLB hearings were held throughout the country, and applications for construction permits considered involved a total of 21 power reactors.

Eleven of the cases which were not contested involved issuance of provisional construction permits to the Metropolitan Edison Co. (Pa.); Consumers Public Power District (Nebr.); Omaha Public

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

[10] The Atomic Safety and Licensing Board Panel office, which was established in 1967 with a permanent chairman and vice chairman, coordinates and supervises the ASLB activities; serves as spokesman for the panel; and presents recommendations to the Commissioners relating to the conduct of hearings, hearing procedures, and policies for the guidance of the boards.

Power District (Nebr.); Virginia Electric & Power Co.; Wisconsin Electric Power Co.; Wisconsin Public Service Co.; Tennessee Valley Authority (Ala.); Public Service Electric & Gas Co. (N.J.); Sacramento Municipal Utility District (Cailf.); Commonwealth Edison Co. (Ill.) and Arkansas Power & Light Co.

Six of the cases were contested and involved applications of the Pacific Gas & Electric Co. (Calif.); Northern States Power Co. (Minn.); Boston Edison Co.; Florida Power Corp.; Public Service Co. of Colorado; and Maine Yankee Atomic Power Co.

In all of the above cases, the ASLB's determined that provisional construction permits should be issued to the applicants. In an additional contested case, involving a Philadelphia Electric Co. application for which the hearing was held in late 1967, the ASLB determined that provisional construction permits should be issued.

An ASLB previously established was reconvened to hold a further hearing involving construction permits for the Florida Power & Light Co. Provisional construction permits had been issued in this proceeding in 1967, but the Commissioners, after review, remanded the proceeding to the ASLB to receive further information on specified issues. At year's end, the board had not issued a supplemental decision in this matter.

Commission Review

During the year, the Commissioners completed or undertook formal reviews of 7 facility licensing matters upon appeals from atomic safety and licensing board decisions.

Oconee Units 1, 2, and 3

The Commissioners reviewed, pursuant to exceptions filed by 11 North Carolina municipalities and Piedmont Cities Power Supply, Inc., an ASLB initial decision authorizing the issuance of class 104b. permits to the Duke Power Co. to construct three nuclear power reactors in Oconee County, S.C. In its decision issued on January 3, the Commission held that the Oconee 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.

Judicial Review. On March 1, 1968, the municipalities and Piedmont filed a petition for review with the United States Court of Appeals for the District of Columbia Circuit contesting the AEC's licensing action. The petitioners contended that the Oconee reactors are not licensable under section 104b. and that the AEC erred in not considering antitrust factors[11] in passing upon the license application. The matter is presently pending before the court.

Vermont Yankee Nuclear Power Station

The State of New Hampshire and a group of Massachusetts municipal power systems (the municipals) contested an ASLB initial decision authorizing the issuance of a provisional construction permit to the Vermont Yankee Nuclear Power Corp. for a nuclear power reactor on the Connecticut River near Vernon, Vt. On April 8, the Commissioners upheld the ASLB's refusal to consider possible thermal effects on the Connecticut River caused by cooling water discharged from the proposed facility. The Commission held that the AEC does not have regulatory jurisdiction over thermal effects under the Atomic Energy Act, and that the Federal Water Pollution Control Act, as amended, and Executive Order 11288 do not enlarge AEC's licensing jurisdiction.

The Commission supported the ASLB's denial of intervention to the municipals, holding that the municipals (who had asserted adverse competitive consequences) had set forth no interest which may be affected by the radiological safety or national security matters involved in a section 104b. licensing proceeding. The Commission held, citing its ruling in the Duke Power Co. decision, that the Vermont Yankee facility was properly licensable under section 104b. of the Atomic Energy Act; and that the AEC lacks 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. The Commission also sustained the ASLB's grant to the Vermont Yankee Nuclear Power Corp. of an interim exemption from the financial qualifications requirements of the AEC's regulations. The Commission further stated that it intended to schedule a hearing to receive evidence on the financial qualifications of Vermont Yankee to design and construct the subject facility and provided that, at such hearing, the legal validity would, among other matters, be appropriate for consideration in determining the corporation's financial ability to meet its radiological safety and national security obligations under the AEC license.

Judicial Review. On April 23, 1968, the municipals petitioned for review of the Commission's ruling to the Court of Appeals for the District of Columbia Circuit. The municipals' earlier (November 1967) petition for review was dismissed under conditions agreed to by

[11] See previous discussion of "Matters Outside the AEC's Jurisdiction" in this chapter.

all parties. The municipals asked that the court direct dismissal of the Vermont Yankee application as one improperly filed under section 104b. of the act or, alternatively, that the municipals be allowed to intervene in a reopened administrative proceeding, and that the Commission determine antitrust issues with respect to Vermont Yankee's application. The matter is presently pending before the court.

On June 14, the State of New Hampshire petitioned the Court of Appeals for the First Circuit (Boston, Mass.) for review of the Commission's licensing action with respect to the denial of AEC jurisdiction over thermal effects. The matter is pending before the court.

Turkey Point Units 3 and 4

On August 6, the Court of Appeals for the District of Columbia Circuit ruled, on a petition for review by an intervenor in the Turkey Point proceeding,[12] that the Atomic Energy Act does not require the AEC to consider, in a licensing proceeding, possible hostile enemy acts against nuclear power reactors, and that the Commission's determination not to do so was well within its statutory authority. In a companion case, filed by the same intervenor, the court upheld a regulation to the above effect (10 CFR § 50.13) and also ruled that the AEC could properly limit public participation in the underlying rule making proceeding to the submission of written comments.

Peach Bottom Atomic Power Station Units 2 and 3

An ASLB in its initial decision dated January 29, authorized the issuance of provisional construction permits under section 104b. to the Philadelphia Electric Co. for a two-unit nuclear power facility to be located on the Susquehanna River in York County, Pa. The ASLB had held hearings on the application December 7 and 8, 1967. The city of Dover, Del., was permitted to intervene in the proceeding for the purpose of contesting the AEC's jurisdiction to issue the permits under section 104b. of the Atomic Energy Act. The intervenor appealed to the Commission the ASLB's decision concerning section 104b. licensability. On June 5, the Commissioners upheld the ASLB's jurisdictional determination on the basis of the rationale in the earlier Duke decision.

On June 17, the Easton (Md.) Utilities Commission petitioned to intervene in this proceeding and for reconsideration of the Commission's decision. The Commissioners denied both petitions on September 6.

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[12] See pp. 131–132, "Annual Report to Congress for 1967."

Judicial Review. On August 2, the Easton Utilities Commission filed a petition for review in the Court of Appeals for the District of Columbia Circuit contesting the Commission's June 5 decision and the subsequent denial of intervention and reconsideration. The matter is pending before the court.

Pilgrim Nuclear Power Station

An ASLB conducted a hearing in Plymouth, Mass., on June 18 and 19, on the Boston Edison Co. application to construct a nuclear power reactor in Plymouth County, Mass. The section 104b. jurisdiction issue was raised in this proceeding by the intervenors—the electric power supply departments of the towns of Braintree and Wakefield, Mass.

On August 26, the ASLB's initial decision authorized issuance of a provisional construction permit to the applicant. Referring to the Commission's decisions in the Duke and the Philadelphia Electric cases, the ASLB held that the facility was properly licensable under section 104b. The intervenors' exceptions to the ASLB decision are pending before the Commission.

Crystal River Unit 3

A hearing to consider the application of Florida Power Corp. for a permit to construct a nuclear power reactor on the Gulf of Mexico in Citrus County, Fla., was held before an ASLB on July 16 and 17 in Crystal River, Fla. The city of Gainesville, Fla., and the city's utilities department were permitted to intervene for the purpose of contesting licensability under section 104b. In a decision on September 24, the ASLB found the facility to be licensable under section 104b. and authorized the issuance of a provisional construction permit. The intervenor filed exceptions with respect to this portion of the decision.

The AEC regulatory staff and the applicant filed exceptions to portions of the ASLB decision which qualified the findings proposed to be made by the Director of Regulation in the Notice of Hearing. All exceptions are pending before the Commission.

Maine Yankee

The group of Massachusetts municipal power systems which sought intervention in the Vermont Yankee proceeding (see above) also petitioned to intervene in a proceeding held before an ASLB on September 18 to determine whether a provisional construction permit should be issued to the Maine Yankee Atomic Power Co. for the construction of a nuclear powerplant in Lincoln County, Maine. The petition to intervene to contest jurisdiction to issue a license under section 104b. was denied by the ASLB. An initial decision authorizing issuance of a provisional construction permit was rendered on October 17. The municipal power systems have filed exceptions, which are pending before the Commission.

IMPROVING THE REGULATORY PROCESS

The AEC's continuing efforts to improve regulatory procedures for licensing reactors during 1968 included initiation of a new review of the program and significant progress in AEC-industry development of safety criteria and standards.

In July, the AEC named a study group [13] to review the regulatory program to help assure that procedures keep pace with the rapid expansion of the nuclear industry. The review, which follows several previous studies by panels from outside the Government and by the Congressional Joint Committee on Atomic Energy, is being conducted by members of the three principal components of the AEC regulatory system—the regulatory staff headed by the Director of Regulation, the Advisory Committee on Reactor Safeguards (ACRS), and the Atomic Safety and Licensing Board Panel (ASLBP). The study is primarily technically oriented and aimed at the following:

(*1*) Timing and coordination in the decision-making process and the review process. This includes a study of the process by which nuclear plants are procured, sited and constructed, and stages where appropriate action can be taken to improve regulatory objectives with a minimum dislocation of the design-construction process.

(*2*) The degree of standardization that may have been reached in reactor design and how this could affect the application of safety standards.

(*3*) Improvement of communication among the principal elements of the regulatory system.

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[13] Members of the study group are Harold G. Mangelsdorf (chairman of the board, Crown Petroleum Co., Short Hills, N.J.), of the ACRS, chairman; Warren E. Nyer, vice chairman, who resigned from the ASLB on Sept. 30, 1968, to assume a position with private industry; Caroll W. Zabel (director of research and associate dean of the Graduate School, University of Houston, Tex.), chairman of the ACRS; Stephen H. Hanauer (professor of nuclear engineering, University of Tennessee, Knoxville), a member of the ACRS; David B. Hall (Los Alamos Scientific Laboratory), a member of the ASLBP; Peter A. Morris, director of the AEC Division of Reactor Licensing; Edson G. Case, director of the AEC Division of Reactor Standards; and John W. Crawford, Jr., assistant director of the AEC Division of Reactor Development and Technology. Marcus A. Rowden, assistant general counsel for the AEC, serves as legal counsel to the group.

Reactor Criteria and Standards

With the cooperation of industry and professional code groups, considerable progress was made during 1968 in developing more detailed safety criteria for light-water power reactors. The cooperative efforts are assuring that the ideas and experience of industry will be incorporated in regulatory criteria and that, in turn, regulatory requirements will be reflected in appropriate industrial codes.

Quality Assurance Prime Goal

Current efforts are primarily concerned with criteria for quality assurance in design, fabrication, and inspection of reactor coolant system components in order to provide the necessary guidance on this important aspect of reactor safety.

Pressure Vessels. The pressure vessel codes sponsored by the American Society of Mechanical Engineers (ASME) have long been recognized as national industrial standards. With the advent of nuclear power, the ASME has supplemented these codes to include additional requirements for nuclear pressure vessels. Significant improvements in fabrication have been incorporated in the 1968 addition of the ASME "Nuclear Pressure Vessel Code." Paralleling the ASME activities, the AEC–ACRS Primary System Review Group developed the "Tentative Regulatory Supplementary Criteria for ASME Code-Constructed Nuclear Pressure Vessels." These were provided to the nuclear industry for comment and interim guidance in August 1967.[14] They are being extensively revised to reflect comments received and to delete those portions adopted in the 1968 revision of the ASME code.

Piping. In a related effort to provide standards for other nuclear reactor coolant systems components, the ASME published, in June 1968, a new "Code for Nuclear Power Piping" for trial use and comments. The AEC–ACRS Primary System Review Group has begun work on AEC regulatory criteria to supplement this code.

Electrical Systems. Efforts have been underway, during the past few years, to develop codes and standards for nuclear powerplant instrumentation, control, and electrical systems. This work is being sponsored by the Institute of Electrical and Electronic Engineers (IEEE) with coordination by the United States of America Standards Institute (USASI). Working groups have been formed by IEEE in the areas of single failure criteria, equipment qualification tests, periodic testing, auxiliary power, and reliability. To date, the IEEE,

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[14] See p. 118, "Annual Report to Congress for 1967."

in cooperation with AEC representatives, has approved "Proposed Criteria for Nuclear Power Plant Protection Systems." Criteria on auxiliary power systems for nuclear powerplants are in an advanced stage of development.

Seismic Criteria. The development of criteria on site-related aspects of nuclear powerplant design and safety has been initiated and carried on by the AEC staff with the aid of other Federal agencies and consultants. A major effort has been devoted to establishment of the principal seismic and geologic considerations for determining the suitability of sites proposed for nuclear reactors. These proposed criteria, which have had extensive reviews by the AEC, ACRS, and consultants, will be made available for public comment in 1969.

Revised Technical Specifications System Adopted

A significant improvement in simplifying and standardizing licensing procedures was completed in December with incorporation into AEC regulations of a new system of technical specifications (license conditions) for nuclear reactors.[15] Technical specifications define vital safety features of the reactor and conditions of operation that cannot be changed without AEC approval. Thus, they are a central feature of the continuing relationship between the licensee and the AEC during the operating lifetime of the reactor.

Designed to eliminate much of the detail not essential to safety which has characterized previous technical specifications, the revised system focuses attention of both licensee management and the AEC on vital safety features. Favorable experience has been gained in applying the new approach to the technical specifications of several reactors recently licensed for operation, including the Connecticut Yankee Atomic Power Co.'s Haddam Neck Plant and Southern California Edison Co.'s San Onofre Nuclear Generating Station.[16]

Under the regulation changes, applicants are given definitive guidance on the types of information needed by the AEC at the construction permit stage and at the operating license stage. To further assist applicants, a "Guide to Content of Technical Specifications" has been prepared, which together with the previously released "Guide for the Organization and Content of Safety Analysis Reports" is expected to expedite review of licensing cases by specifying more clearly the information needed by the AEC in its safety evaluation.[17]

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[15] Amendment to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," effective 30 days after publication in the *Federal Register* of December 17, 1968.

[16] Proposed technical specifications system was published in August 1966 for comment and interim guidance. See p. 38, "AEC Annual Report to Congress for 1966."

[17] These guides may be obtained from the Commission's Public Document Room, 1717 H Street NW., Washington, D.C., or by writing to the Director, Division of Reactor Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545.

FINANCIAL INDEMNIFICATION

In 1968, as in all 11 previous years, no claims were made under the licensee indemnity agreements established by the Price-Anderson Act of 1957. Under the indemnity program, the public, AEC facility licensees, and contractors are afforded financial indemnity against public liability risks associated with nuclear energy. A maximum of $560 million to cover public liability claims that might conceivably arise from a nuclear incident is provided under the program by means of a combination of private insurance and governmental indemnity.

Waivers of Defenses

Effective on November 30, 1968, the AEC regulation, 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements," was revised to reflect 1966 amendments to the Price-Anderson Act relating to "extraordinary nuclear occurrences" and waivers of defenses.[18]

The amendments to part 140 established criteria by which the AEC would make a determination as to whether an "extraordinary nuclear occurrence" had taken place (in general terms, "extraordinary nuclear occurrence" means the discharge of substantial amounts of radioactive material from a facility which has resulted, or will probably result, in substantial damages to persons offsite). The amendments also specify the defenses which must be waived by the licensee and others in the event of an "extraordinary nuclear occurrence." Thus, persons suffering damage from a nuclear incident which meets the criteria will have additional assurance of prompt financial compensation for damage resulting from hazardous properties of radioactive material or radiation.

All current indemnity agreements and financial protection insurance policies were also amended in 1968 to provide for waivers of defenses as required in the 1966 amendments to the Price-Anderson legislation and the 1968 revision of part 140.

Refund of Insurance Premiums

Under the industry credit rating plan established by the two nuclear energy liability pools, a major portion of the annual premiums paid for nuclear liability insurance is set aside as a reserve for ultimate return to policyholders after 10 years if not used for the payment of losses. In the eleventh policy year, 1967, the two pools, Nuclear

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[18] See p. 41, "Annual Report to Congress for 1966."

Energy Liability Insurance Association (NELIA), and Mutual Atomic Energy Liability Underwriters (MAELU), paid out the first refund to holders of policies in 1957.[19] In 1968, refunds totaling $241,209 were paid by the pools. This figure represented 67.5 percent of the total premiums paid in 1958 by the affected policyholders, and 99.2 percent of the reserve established from those premiums.

Increased Private Insurance

In December, the two private nuclear energy insurance pools (NELIA and MAELU) informed the AEC that effective January 1, 1969, their combined underwriting capacity for nuclear energy liability insurance would be increased from $74 million to $82 million. Amendments to AEC regulations to reflect the increases were being prepared at year's end.

Indemnity Agreements in Effect

The licensed operation of 13 power reactors, five testing reactors, 77 research reactors, 16 critical facilities, the N.S. *Savannah*, and a chemical reprocessing facility; the storage of nuclear fuel prior to operation of a reactor at nine sites; and one construction permit were covered in the 92 active indemnity agreements with AEC licensees in effect at the end of 1968.

Indemnity fees[20] earned by AEC during 1968 totaled $190,388. Since the inception of the program, indemnity fees earned by the AEC have totaled $924,063.

CONTROL OF MATERIALS

Continued expansion and diversification in uses of atomic energy materials, new actions to simplify and facilitate AEC materials licensing, transfer of certain AEC regulatory authority to two more States, and strengthening of measures to safeguard special nuclear materials used by licensees, characterized 1968. By year's end, more than 15,600 materials licenses were in effect in the combined programs of the AEC and 19 Agreement States, of which some 90 percent were for the possession or use of radioisotopes.

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[19] See p. 134, "Annual Report to Congress for 1967."

[20] The annual indemnity fee payable to the AEC is $30 per authorized thermal megawatt for licensed reactors, with a minimum charge of $100.

AEC MATERIALS LICENSING PROGRAM

Although the AEC transferred 223 licenses to the regulatory control of two more States in 1968, the continuing expansion in atomic materials usage maintained the number of AEC licenses near the total in effect at the end of the previous year. During the year, nearly 8,000 applications for licenses, amendments, and renewals were filed with the regulatory staff. On December 31, 1968, 9,234 AEC licenses were in effect, consisting of 8,317 for byproduct materials(radioisotopes), 378 for source materials (uranium or thorium), and 539 for special nuclear materials (plutonium, uranium-233, or enriched uranium) which are used as fuel in nuclear power reactors.

Among the 1968 license applications of particular interest were those filed in connection with the proposed operation of a new uranium concentrate sampling plant and two new fuel fabrication plants, reflecting increased activity to accommodate fuel requirements of the growing number of nuclear power reactors.

Concentrate Sampling Plant

In February, Lucius Pitkin, Inc., was issued AEC's first source material license to operate a commercial uranium concentrate sampling plant. The plant, located in Metropolis, Ill., receives drummed concentrates produced by both domestic and foreign mills. The concentrates are weighed, sampled, analyzed, and then delivered to Allied Chemical Corp.'s nearby facility where the concentrates are converted to uranium hexafluoride.

New Fuel Fabrication Plants

A license application for a new fuel fabrication plant at Wilmington, N.C., was received from the General Electric Co. In addition, Westinghouse Electric Corp. applied for a license to use small quantities of enriched uranium for testing at its new facility planned for Columbia, S.C. Both plants are designed to fabricate fuel elements using uranium hexafluoride as the starting material. The license for the GE plant was not issued; the Westinghouse application was under review at the year's end.

Thermoelectric Generators

Two licenses were issued during 1968 to use radioisotope power generators in undersea offshore locations. In April, a license was issued to the U.S. Navy authorizing use of a 125,000-curie strontium-90

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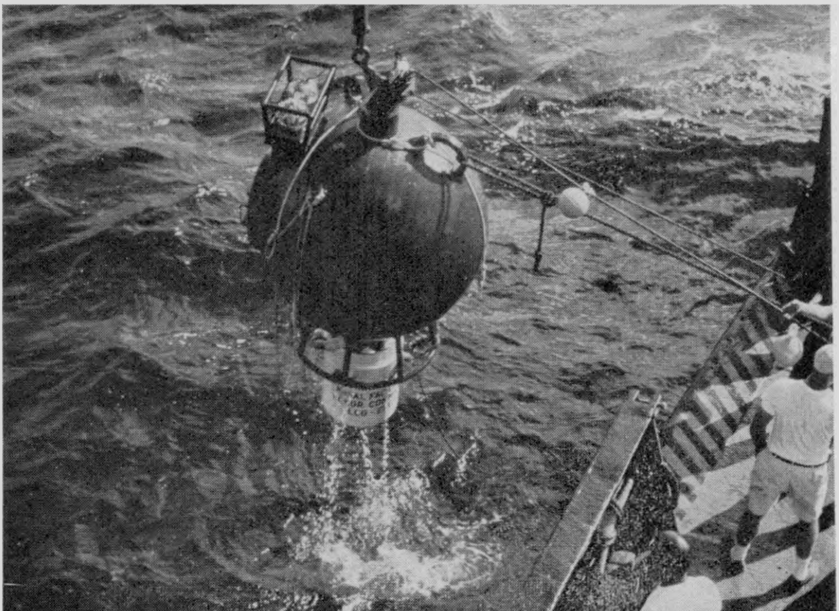
power unit with an underwater buoy platform 18 miles south of Ponce, P.R., to collect oceanographic data. The generator provided the buoy system's electrical power and battery-charging power for telemetry until the Navy removed the buoy system in May because of electric failure external to the generator.

In November, Aerojet General Corp. was authorized to use a 7,200-curie strontium-90 thermoelectric generator as an experimental navigational benchmark off the coast of California.

Radiopharmaceuticals

During the year, a large number of physicians and hospitals were authorized to use a device for the convenient preparation, in pharma-



A Thermoelectric Generator for an Underwater Buoy was planted underwater by the U.S. Navy in the Caribbean Sea about 18 miles south of Ponce, P.R. An AEC license authorized the use of a thermoelectric generator for the device containing 125,000 curies of strontium-90 in the form of encapsulated strontium titanate. The buoy system was designed by the Naval Facilities Engineering Command to collect oceanographic data for transmission to a Nimbus "B" satellite for storage and later ground station acquisition. The isotopic generator provided buoy system instrument electrical power and battery charging power for telemetry.

ceutical form,[21] of technetium-99^m, a radioisotope which has not been readily available for hospital use because of its short half-life (a few hours). The device, called a radionuclide generator, permits extraction of the technetium as it is produced from molybdenum-99, through a radioactive decay process. A major advantage of using short half-lived materials is that the patient receives a low radiation dose. Technetium-99^m [22] in one chemical form is used routinely in nuclear medicine for brain scanning, and experimentally for lung, liver, spleen, bone marrow, and heart scanning. By December 31, 1968, the AEC had reviewed and approved for licensing 21 molybdenum-99/technetium-99^m generators, supplied by six manufacturers.[23]

Hot-Cell Gamma Irradiators

An increase in licenses for hot-cell commercial facilities for irradiating chemicals, woodplastics and food products, and for sterilization and radiation research occurred in both 1967 aand 1968. Since January 1967, operating licenses have been issued for 15 such facilities using from 10,000 to 2 million curies of radioactivity. Only five such hot-cell irradiators were licensed before 1967. Table 4, on p. 135, indicates the hot-cell irradiation facilities licensed to date.

SIMPLIFYING THE LICENSING PROCESS

Several actions were taken in 1968 toward simplifying and expediting materials licensing procedures. Some of these reflect recommendations of the *ad hoc* Radioisotopes Licensing Review Panel which conducted a 6-month study of the AEC program during 1967.[24] These regulatory actions are part of the AEC's continuing effort to streamline the regulatory process and develop more definitive safety criteria to assure protection of public health and safety in a period of rapid growth in atomic energy uses.

Specific Licenses of Broad Scope

Wider use of broad licenses for research and development are now permitted. A rule change [25] provides three types of broad licenses

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[21] The AEC is assisted in evaluations of new radioactive pharmaceutical products by its Advisory Committee on Medical Uses of Isotopes, listed in Appendix 2.

[22] See pp. 222–224, "Fundamental Nuclear Energy Research–1967."

[23] Abbott Laboratories, North Chicago, Ill.; E. R. Squibb & Sons, Inc., New Brunswick, N.J.; Mallinckrodt Nuclear, St. Louis, Mo.; New England Nuclear Corp., Boston, Mass.; Cambridge Nuclear Corp., Cambridge, Mass.; and Neisler Laboratories, Inc., Tuxedo, N.Y.

[24] See pp. 135–137, "Annual Report to Congress for 1967."

[25] Effective and proposed amendments of AEC regulations dealing with licensing and regulation which were published in 1968 are summarized in Appendix 5.

covering simple to complex research and development programs involving use of very high to low levels of radioactivity. These licenses are intended to reduce administrative effort of both licensees and the AEC, and to permit greater flexibility for specially qualified licensees in the use of a wide variety of radioisotopes without relaxing health and safety standards.

One of the Mobile Irradiators in operation for AEC studies on irradiation processing of foods to prolong the storage life is shown as technicians prepare to irradiate lemons at the University of California's Davis Campus. This irradiator is mounted on a truck for easy movement between crop harvests.

Product Class Exemptions

A program for exempting from licensing requirements certain classes of products containing radioisotopes was initiated. Proposed regulation changes would establish class exemptions for: (*a*) self-luminous products containing tritium, krypton-85, and promethium-147, and (*b*) byproduct material contained in gas and aerosol detectors for protection of human life and property. Appropriate safety criteria for authorizing distribution of products under the proposed exemptions have been developed.

TABLE 4.—HOT-CELL IRRADIATOR FACILITIES LICENSED BY AEC

Licensee	Authorized quantities (curies)[1]	Purpose	Issue date
U.S. Department of Interior, Bureau of Mines, Albany, Oreg.	175,000	Irradiation studies chemical and fuels.	September 1961.
U.S. Army, Natick Labs, Natick, Mass.	2,200,000	Food irradiation studies	September 1962.
Ethicon, Inc., Somerville, N.J	800,000	Sterilization of medical products.	August 1964.
U.S. Department of Interior, Bureau of Commercial Fisheries, Gloucester, Mass.	275,000	Marine products irradiation	April 1965.
American Novawood Corp., Lynchburg, Va.	400,000	Commercial irradiation of wood products.	January 1966.
Lockheed Aircraft Corp., Lockheed-Georgia Co., Marietta, Ga.	250,000	Commercial irradiation	January 1967.
Dow Corning Corp., Midland, Mich.	25,000	Research and development	Do.
National Aeronautics and Space Administration, Huntsville, Ala.	26,000	Spacecraft component irradiation.	Do.
Dow Chemical Co., Midland, Mich.	100,000 (Cs^{137}) or 15,000 (Co^{60})	Research and development and chemical processing.	February 1967.
Dow Corning Corp., Midland, Mich.	144,000	Chemical processing	April 1967.
Michigan State University, East Lansing, Mich.	55,000	Food irradiation studies	May 1967.
Isotopes, Inc., (Mobile Unit), Westwood, N.J.	170,000 (Cs^{137})	Food irradiation and demonstrations.	Do.
Gamma Process Co., Inc., New York, N.Y.	200,000	Commercial irradiations and source loading.	June 1967.
Hawaii Department of Agriculture, Honolulu, Hawaii.	250,000	Food irradiation studies	Do.
U.S. Department of Agriculture, Beltsville, Md.	30,000	Grain and food irradiation studies.	July 1967.
Indiana State Univ., Terre Haute, Ind.	10,000	Irradiation studies	Do.
Neutron Products, Inc., Dickerson, Md.	2,000,000	Source distribution and irradiation studies.	February 1968.
Nuclear Materials and Equipment Corp., Apollo, Pa.	1,050,000	Commercial irradiations	March 1968.
University of Missouri, Columbia, Mo.	12,000	Irradiation studies	June 1968.
National Aeronautics and Space Administration, Greenbelt, Md.	30,000	Spacecraft irradiation studies	September 1968.

[1] Radioactive material used is cobalt-60 unless otherwise indicated.

Exempt Small Quantities

A comprehensive schedule was established designating small quantities of radioisotopes that can be used under an exemption from licensing requirements. Safety in the use of such materials will be controlled by requirements on the suppliers of the exempt quantities concerning packaging, labeling, limitations on transfer, and safety brochures which would accompany packages of exempt quantities.

General Licenses

General licenses permit possession or use of specified materials within stated limitations. They are effective without requiring individual applications from, or issuance of licensing documents to, particular persons.

Ownership of Special Nuclear Materials. In August, the AEC amended its regulations to provide a general license for the ownership of special nuclear materials (plutonium, uranium-233, and uranium enriched in U^{233} or U^{235}). These materials can be used as fuel in nuclear power reactors. Under the amendment, an individual or firm which owns such material but which does not physically possess or use it, will not be required to have a specific license. This general license for mere ownership serves to simplify and expedite the AEC's regulatory processes without prejudicing in any way AEC controls over possession, use, and physical transfer of special nuclear materials. Similar general licenses for the ownership of byproduct material (radioisotopes) and source materials (uranium and thorium) have been in effect for several years.

Generally Licensed Devices. Since November 1967, the AEC has authorized the generally licensed distribution of seven new devices using byproduct material. These devices use quantities of radioisotopes ranging from 0.5 millicuries of americium-241 to 6 curies of tritium (hydrogen-3) for functions varying from determination of zinc coating thickness of a galvanizing process to measuring and recording the speed and direction of underwater currents at ocean depths exceeding 15,000 feet. During this same period the AEC authorized the exempt distribution of automobile lock illuminators containing up to 2 millicuries of promethium-147.

In another action, the AEC made rule changes establishing a general license for the use of iodine-125 and iodine-131 for *in vitro* [26] clinical or laboratory tests.

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[26] *In vitro:* outside the body—usually involving laboratory apparatus, as opposed to *in vivo*—in the body.

Export of Materials

Most exports of AEC-licensed material are made under general licenses which do not require individual licensing approval. Specific licenses are required for exports in forms or quantities not authorized under a general license, to destinations to which exports may not be made under general license, and for all exports of special nuclear material. In 1968, the AEC issued 211 specific licenses for export, including 47 licenses for export of byproduct or source material to Eastern European countries. Special nuclear material was exported under license for the first time in 1968. Nine such SNM licenses have been issued to date.

Export of Uranium as Shielding. In August, the AEC amended its regulations to permit the export under general license of natural or depleted uranium when fabricated as shielding and contained in radiographic exposure or teletherapy devices.

The new general license, which requires no application to AEC, permits exports of up to 500 pounds of uranium per device to any foreign country or destination, except Albania, Bulgaria, China (including Manchuria, but excluding Taiwan), Cuba, Communist-controlled area of Vietnam, Czechoslovakia, East Germany (Soviet Zone of Germany and East Berlin), Estonia, Hungary, Latvia, Lithuania, North Korea, Poland (including Danzig), Outer Mongolia, Rumania, Southern Rhodesia, and the Union of Soviet Socialist Republics. A general license has also been provided authorizing the export of uranium in the devices to Southern Rhodesia if used in medical diagnosis or therapy.

The devices in which the uranium is contained as shielding are used for industrial quality control and for medical purposes. The AEC determined that the export of uranium in this form, and in the quantities specified, would not be inimical to the interests of the United States.

STATE REGULATORY AGREEMENTS

In recognition of the interests of the States in the peaceful uses of atomic energy, section 274 of the Atomic Energy Act of 1954, as amended, authorizes the AEC to enter into agreements with States for the transfer of regulatory authority over byproduct, source, and small quantities of special nuclear materials. Before entering into an agreement, the AEC must find that the State's program is adequate to protect the public health and safety and is compatible with the AEC's regulatory program.

New Agreements

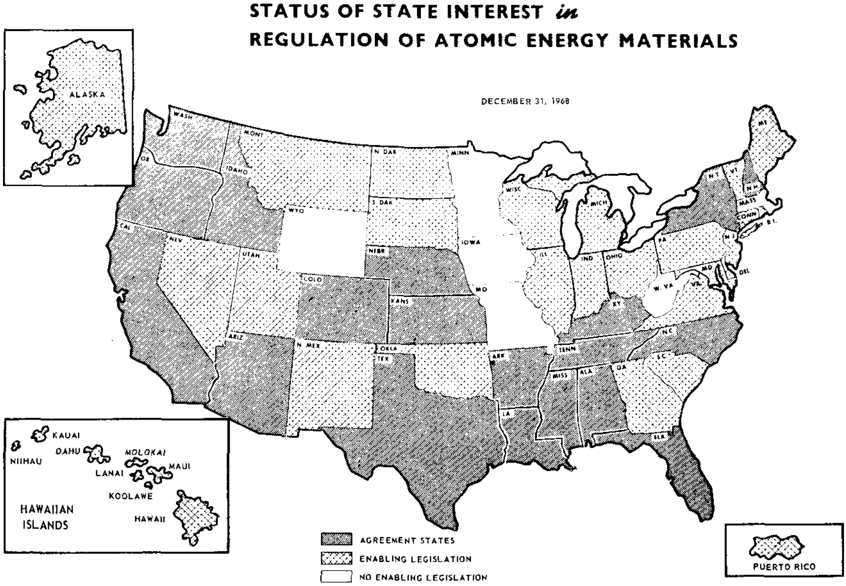
In 1968, Colorado and Idaho signed agreements with the AEC for the assumption of certain of the AEC's authority to regulate the private uses of atomic energy materials, bringing the total number of Agreement States to 19. A number of other States demonstrated their interest in exercising similar health and safety responsibilities for their citizens by preparing for an agreement.

Under the new agreements, Colorado (effective Feb. 1, 1968) and Idaho (effective Oct. 1, 1968) assumed regulatory authority over 179 licenses and 44 licenses, respectively. Other States which had earlier signed agreements with the AEC for the regulation of atomic energy materials are Alabama, Arizona, Arkansas, California, Florida, Kansas, Kentucky, Louisiana, Mississippi, Nebraska, New Hamsphire, New York, North Carolina, Oregon, Tennessee, Texas, and Washington. About 41 percent of the estimated more than 15,600 licenses in effect in the United States now are under the regulatory authority of the 19 Agreement States.

Post-Agreement Cooperation

To assist in maintaining continuing adequacy and compatibility of State programs, the AEC conducts a postagreement program of cooperation with States. This program provides for the exchange of

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



current information on regulations, licensing, inspection and enforcement data; consultation on special regulatory problems; periodic meetings (usually semiannually) to review the current status of each State's program; and annual meetings with all Agreement States to consider regulatory matters and policies of common interest.

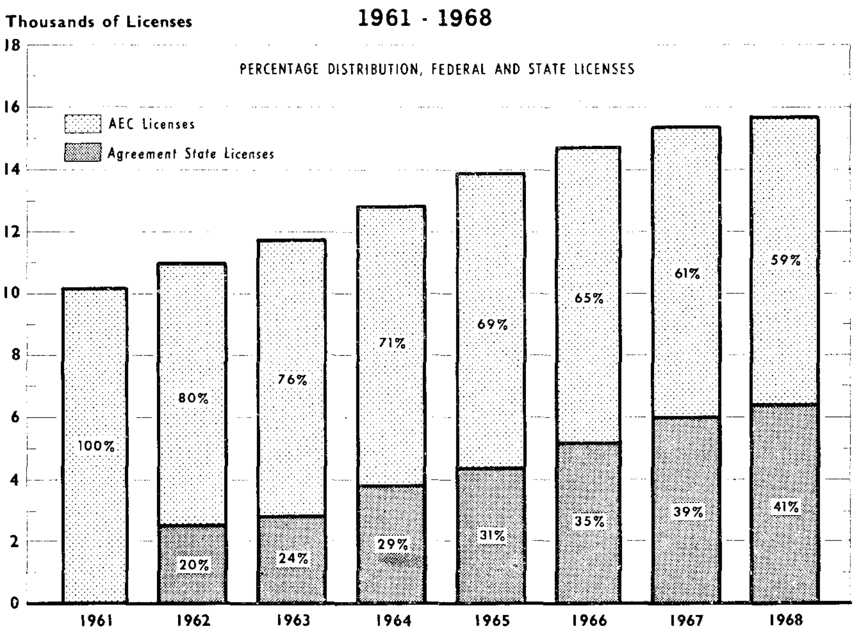
Section 274 of the Atomic Energy Act contains requirements for the continued adequacy of Agreement State regulatory programs to protect public health and safety. In addition, each agreement provides that the AEC and the State will use their "best efforts" to maintain compatible regulatory programs.

In early 1968, the AEC conducted its annual review of the status of each Agreement State program, and on April 9, 1968, made a finding that the programs of the then 18 Agreement States continued to be adequate to protect public health and safety and compatible with the AEC program.

Training Assistance to State Personnel

The AEC sponsors technical training courses to assist State regulatory personnel in preparing for and administering their radiation control programs. A 10-week course in health physics and radiation

ATOMIC ENERGY MATERIALS LICENSES IN EFFECT
1961 - 1968



protection was given twice in 1968 by Oak Ridge Associated Universities (ORAU). A total of 24 persons attended these courses, representing 21 States. To provide practical experience in radiation control for State personnel who have a theoretical background in health physics, a 3-week applied health physics course also was given by ORAU. Eight representatives from six States attended.

Two 1-week courses in specialized subjects were given on a regional basis for State regulatory personnel. A course in the radiation safety aspects of medical uses of radionuclides was conducted by Baylor University Medical School at Texas Medical Center (Houston), with 15 participants from eight southwestern States. A course in regulation of radiographic uses of byproduct material was given at Kansas State University with 11 participants from six States.

In addition, two courses were given at AEC headquarters on the AEC's regulatory practices and procedures. Nineteen people representing 13 States attended these courses.

COMPLIANCE AND ENFORCEMENT

During 1968, AEC personnel performed 2,406 inspections of activities being conducted under materials licenses and 489 inspections of reactor facilities.

Enforcement orders were issued to two licensees as the result of violation of AEC regulatory requirements.

In one instance, the AEC refused to renew a special nuclear material license and ordered the licensee to dispose of all material possessed under the license, and to decontaminate its facilities. Contamination had been spread as a result of a radiation incident in which employees attempted to remove the outer encapsulation of a neutron source in an unauthorized area. (See "Radiation Incidents," summary.) An enforcement order was issued to another licensee because the licensee had modified and conducted operations in areas of its plant without first receiving the necessary amendments to its license which it had requested. The order required the licensee to cease activities in the two areas until the AEC had approved appropriate license amendments.

In 2.5 percent of the inspections of materials licensees and in 5.4 percent of inspections of operating reactors, the AEC inspectors found items of noncompliance with regulatory requirements that required transmittal to AEC headquarters for enforcement action.

Safety in Atomic Energy Industry

Surveys of injury frequency and severity rates again showed the work-injury experience of the atomic energy industry to be better than recent averages for all manufacturing industries as compiled by the Bureau of Labor Statistics (BLS).

The latest BLS survey of the atomic energy industry, covering industrial injuries from all causes in 1967, showed a frequency rate of 4.7 disabling injuries for each million man-hours worked, and a severity rate of 277 days lost per million man-hours worked because of injuries. The 1967 frequency rate equaled that of 1966, but the severity rate was substantially lower than the 1966 and 1965 rates of 539 and 514, respectively.

Radiation Exposure Statistics

To obtain information on radiation exposure to licensee employees below those levels that must be reported by regulation, the AEC again contracted with four leading film badge companies [27] to supply summary statistics on film badge readings of employees of licensees using these services in 1967. The data covered 2,720 AEC licensees and about 76,000 of their employees. Very low levels of exposure were generally indicated—the badges of about 95 percent of the employees showed an exposure of less than 1 rem [28] during 1967, and badges of 71 percent of all employees showed an exposure of less than 0.1 rem for that year.

RADIATION INCIDENTS

During the year, 17 radiation incidents were reported by AEC licensees as required by regulations.[29] AEC personnel investigated each incident to determine its cause, extent of radiation exposure to persons, adequacy of licensee efforts to prevent recurrence, and need for licensing or enforcement action.

Eight of the 17 incidents occurred during radiographic (nondestructive testing or inspection) operations. The maximum exposure was 800 rems, to the hand of a radiographer. The highest whole-body exposure was 36 rems, also to a radiographer. In seven of these incidents the source failed to return to the shield and the exposure was received either because the radiographers did not perform the required radiation detection survey, did not perform an adequate survey, or misinterpreted the instrument reading. In the eighth incident, the radiographer did not return the source to the shield after making a

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

[28] 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.

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

radiograph. His assistant received a dose of 230 rems to the shoulder when he picked up the tube with the source still unshielded.

Seven incidents involved the spread of radioactive contamination and temporary loss of use of facilities. In one incident, two employees inhaled significant quantities of plutonium-238. Whole-body counting indicated that the amount of plutonium-238 in the lungs of the employee receiving the highest exposure could result in a maximum annual dose to the lungs of 10 to 13 times the limit recommended by the Federal Radiation Council and the International Commission on Radiological Protection. The incident occurred when the two employees attempted to remove the outer encapsulation of a 35-curie, plutonium-238/beryllium neutron source with a hacksaw in an area where there were no provisions for control of contamination. The other six incidents involved: spread of plutonium-239 contamination from a plutonium foil in a laboratory; a spill of phosphorus-32 in a medical laboratory; spread of contamination resulting from implosion of a flask containing methanol and a tritiated compound; contamination of a research reactor facility from the bursting of an irradiated stone meteorite sample (sodium-24) ; the contamination of a laboratory from the rupture of an americium-241 source; and the contamination of several laboratories with molybdenum-99 from the malfunction of a solvent extraction system.

In one of the remaining two incidents, an individual entering a hot cell received a calculated whole body exposure of about 28 rems when a monitoring device outside the cell failed to indicate the presence of an exposed cobalt-60 source. In the other incident, the failure to evaluate the hazards incident to the processing of cobalt-60 sources caused an employee engaged in the operation to receive an exposure of 135 rems to his left hand and 81 rems to his right hand.

Lost Radioactive Material

Licensees reported 36 losses of radioactive material during 1968; in five of the instances the missing material was subsequently recovered. In one instance where the material was recovered, a missing source was located by use of a low flying airplane carrying sensitive radiation monitoring instrumentation. In those cases where the material was not recovered, five sealed sources were lost in petroleum wells during well logging operations and were subsequently cemented in place. Two losses occurred in the ocean, one during naval operations and the other during a deep sea drilling project. There were also seven instances where radioactive material was disposed of as scrap and ultimately buried or incinerated.

In the other 17 cases where the radioactive material was not recovered, the AEC determined that the lost material did not constitute a hazard to the public because of the level of radioactivity involved, or other circumstances.

AEC LICENSE FEE SCHEDULE ADOPTED

Effective on October 1, 1968, the AEC adopted a schedule of fees to be charged for licenses.[30]

Under the schedules (see Tables 5 and 6) fees will be charged for: (*a*) licenses to construct and to operate nuclear reactors and other production or utilization facilities; (*b*) licenses for byproduct material (radioisotopes) of 100,000 curies or more in sealed sources used for irradiation of materials; (*c*) licenses for special nuclear material in quantities sufficient to form a critical mass (except plutonium/beryllium neutron sources); and (*d*) waste disposal licenses specifically authorizing the receipt of radioactive materials for commercial disposal.

TABLE 5.—SCHEDULE OF FACILITY LICENSE FEES

Facility: Thermal megawatt (Mwt.) values refer to the maximum capacity stated in the permit or license [1]	Application fee for construction permit	Construction permit fee	Operating license fee	Annual Fee after issuance of operating license
1) Power reactor	$2,500	$5,000+ $10/Mwt.	[2] $2/Mwt.	[2] $2/Mwt.
(2) Testing facility	800	3,000	1,000	1,000
(3) Research reactor	300	2,000	500	500
(4) Other production or utilization facility	1,500	5,000	2,000	2,000

[1] Amendments reducing capacity do not entitle the applicant to a partial refund of any fee; applications for amendments increasing capacity to a higher fee category are not accepted for filing unless accompanied by the prescribed fee less the amount already paid.
[2] Megawatt thermal (Mwt.).

TABLE 6.—SCHEDULE OF MATERIALS LICENSE FEES

Category of materials license	Application fee	Annual fee
1. Licenses for byproduct material of 100,000 curies or more in sealed sources used for irradiation of materials	$500	$100
2. Licenses for special nuclear material in quantities sufficient to form a critical mass, except for licenses authorizing possession and use of plutonium-beryllium neutron sources	300	100
3. Waste disposal licenses specifically authorizing the receipt of waste byproduct material, source material, or special nuclear material from other persons for the purpose of commercial disposal by land or sea burial by waste disposal licensee	500	200

[30] Adopted in accordance with Title V of the 1952 Independent Offices Appropriation Act (65 Stat. 290; 31 USC 483a) and established Administration policy on recovery of user charges.

In general, fees are not charged for export licenses, government agency licenses, and licenses issued to nonprofit educational institutions for materials or facilities used for training, teaching, or medical purposes. Study is continuing on fees for material licenses not now covered in the schedule, which is contained in a new 10 CFR Part 170 of AEC regulations.

License fees paid to the AEC during the 3 months they were in effect in 1968 totaled $170,540.

Chapter 7

OPERATIONAL AND PUBLIC SAFETY

HAZARDS PROTECTION

The protection of persons and property against potential hazards in AEC activities has been a primary concern from the earliest developments in the use of atomic energy. A new technology and a safety program adapted to the AEC's special purposes have evolved simultaneously. The AEC's goal is to develop and use this vital national resource to the extent consistent with a high degree of safety. Actually, the atomic energy industry, according to the National Safety Council, is one of the safest industries in the nation.

Early this year, the AEC and its contractors were presented with the National Safety Council's Award of Honor for 1967 (the sixth such award received in as many years) for the safest year in the AEC's history; however, the 1968 safety record has proven to be even better in that: (*a*) only three fatalities occurred—none caused by radioactivity—as compared with 10 in 1967; and (*b*) the frequency of injuries—none from radioactivity hazards—decreased.

Operations Activities

Uranium Mill Tailings

In October, the AEC and the U.S. Public Health Service completed a joint sampling program to evaluate the public health aspects of radon, a gas produced by radioactive decay of radium, at and near uranium mill tailings in the Colorado River Basin States.[1] The program was carried out with the cooperation of the State health departments of Colorado and Utah and milling companies at Grand Junction and Durango, Colo., and Salt Lake City, Utah.

[1] See pp. 148–150, "Annual Report to Congress for 1967."

The sampling results show that, at each of the sites, no radon was detectable above the natural background levels, except in the immediate vicinity of the tailings piles, where an earth covering substantially reduces radon release. The risk, if any, of radiation exposure to the surrounding population, is negligible.

Uranium Mining

Considerable improvement in the mine environment has been achieved through increased mine ventilation and better distribution of fresh air to the working areas. Improved monitoring of mine air conditions,[2] control of radiation hazards, and the recordkeeping required by Federal and State regulations adopted in 1967, according to industry reports, necessitated a three-fold increase in health and safety staff employment and a five-fold increase in the number of radon samples collected by company personnel. Recent Bureau of Mines inspection reports note that the percentage of workers exposed to no more than one working level [3] had been reduced to 20 percent; previously, more than 30 percent had been exposed.

The Interdepartmental Coordinating Committee, composed of the Chairman, Atomic Energy Commission; Secretary of Health, Education, and Welfare; Secretary of the Interior; Secretary of Labor; and the Director of the Bureau of the Budget, has continued to support Federal agency research and development efforts to improve uranium mine environment and to encourage the exchange of information among the agencies. Steps to accomplish some of the recommendations made by the subcommittee have already been taken.

During 1968, the AEC worked closely with the Federal Radiation Council (FRC), an advisory body to the President on radiation matters, to follow the improvement in the uranium miners' environment as reported by Federal and State agencies and industry. The reports, and other available information, were used for reevaluating the guidance for control of radiation hazards in uranium mining contained in FRC Report No. 8.[4]

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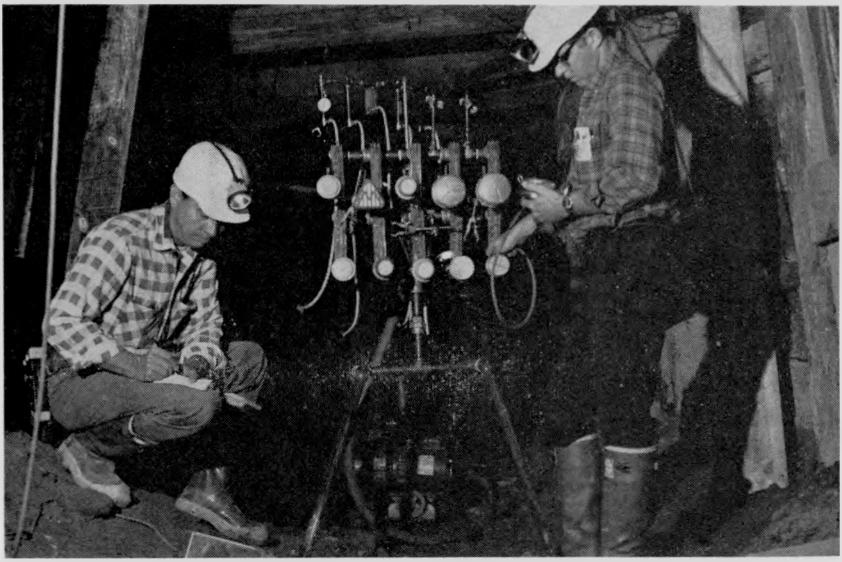
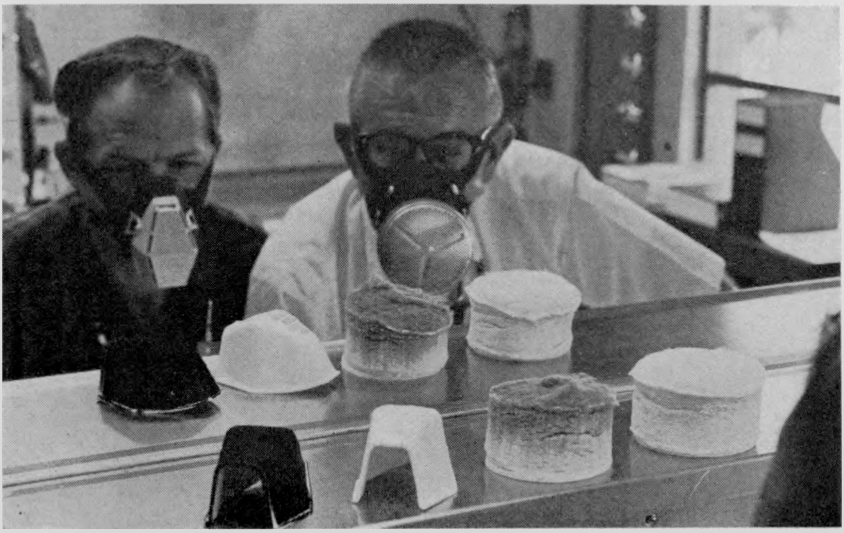
[2] See pp. 205–206 of the supplemental "Fundamental Nuclear Energy Research—1968," report.

[3] A "working level" is defined as any combination of radon daughters in 1 liter of air which will result in the ultimate emission of 1.3×10^5 million electron volts of potential alpha energy.

[4] "Guidance for the Control of Radiation Hazards in Uranium Mining," available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $0.40 a copy.



Uranium Miners' Safety research includes testing filters and respirators in mines as well as in the laboratory. Photo *above* shows 10 face mask filters being tested at a time in the haulageway of a mine in the Lake Ambrosia area near Grants, N. Mex., as part of a joint Los Alamos Scientific Laboratory-State of New Mexico program. The studies seek to provide a miner's mask filter which will keep radon daughter products and other irritants, such as diesel exhaust, out of the lungs. *Below*, LASL technicians use a mirror to model two types of face masks in the occupational health laboratory. The exposed filters at *left*, and *third from left*, have been tested against diesel fumes in the lab. Thus, it is possible to check the performance of new products before issuance to uranium miners. The efficiency of 33 kinds of filters tested ranged from 99 percent down to 10 percent.



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Pollution Control

Executive Orders governing control of air and water pollution at Government-owned facilities required Federal agencies to develop plans for upgrading existing facilities to comply with pollution control standards and requirements by mid-1972.

All of the capital improvement projects included in the AEC's water pollution abatement plan have been completed. The required improvements were minor, involved no additional waste water treatment facilities, and were accomplished at a capital cost of approximately $265,000. More than one-third of the air pollution abatement projects have been completed or are nearing completion. The remainder are in the planning stage.

Columbia River Survey. In September, U.S. Geological Survey (USGS) hydrologists reported that the low levels of radioactivity in Columbia River water and sediments do not represent a hazard to people. Average daily radioactivity levels in water decreased by 50 percent during the period between 1964 and 1966 after three of the Hanford production reactors were shut down. Chromium-51 and zinc-65 are the two major radioactive materials carried into the river with cooling waters used in the production reactors. Concentrations of these radioelements in the river at Richland, Wash., did not exceed 2 percent of the established standards for drinking water—at no time since the production operations began at Hanford in 1944 have the concentrations of radioactivity in river water exceeded the nationally established standards for controlling exposure to people.

At Pasco, 45 miles downstream from the reactors, the level of chromium-51 decreased from 44 curies per billion gallons of water in January 1964, to near 16 curies per billion gallons in September 1966. The USGS study was begun in 1962 and covered the years through 1966; the report was issued in the fall of 1968. Since the survey was made, two additional Hanford production reactors have been shut down (see also "Nuclear Materials Production" summary in Chapter 1—"Source, Special, and Byproduct Nuclear Materials").

Columbia River Thermal Effects Studies

The AEC and the Department of the Interior's Federal Water Pollution Control Administration and Bureau of Commercial Fisheries, have joined in a study of thermal effects in the Columbia River. The chief aim of the 2-year study, announced by the Secretary of the Interior in February, is "to provide a scientific basis for determining permissible variations in stream temperatures above natural levels." The AEC and its Hanford contractors have been studying the effects of thermal discharges from the production reactors to the Columbia River since 1946; the studies have disclosed no adverse effects on the river or its fisheries resources.

Offsite Monitoring Activities

The data collected by AEC's system of environmental monitoring at each major facility are summarized semiannually in *Radiological Health Data and Reports*, a monthly publication of the U.S. Public Health Service (USPHS).[5] Radioactivity levels detected in areas around nuclear facilities were less than the levels of radioactivity acceptable under AEC radiation protection standards and the Federal Radiation Council radiation protection guidelines. Offsite radiological monitoring around the Nevada Test Site (NTS), including the Nuclear Rocket Development Station (NRDS), and other test areas in Central Nevada, and on Amchitka Island, is conducted for the AEC by the USPHS. A summary of the collected data is also published in *Radiological Health Data and Reports*.[6]

NTS Radioactivity Detections

During 1968, there were 29 announced underground weapons development or Department of Defense (DOD) tests, and 4 Plowshare experiments. One underground nuclear test detonation was conducted in Central Nevada. Detectable levels of radioactivity were measured offsite, by ground monitoring, from only four of the nuclear detonations: Hupmobile, January 18; Cabriolet, January 26; Buggy, March 12; and Schooner, December 8. The Cabriolet, Buggy, and Schooner events were Plowshare excavation experiments and some offsite radioactivity was expected.

Safety of AEC-Owned Reactors

During 1968, 27 AEC prime contractors exercised operational control over 76 stationary reactors, one propulsion reactor test stand, one propulsion reactor test cell, and 33 critical facility cells that are owned by the AEC. About 1,500 individual reactor personnel were involved in the operation of these facilities. At the end of the year, there were two AEC reactors under construction and one in planning.

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

[6] Additional data may be purchased from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. 22151.

The AEC headquarters and field safety staffs devoted approximately 43 man-years of effort during 1968 to functions aimed directly at assuring safe operation of AEC facilities. These efforts, along with those of the operating contractors, have resulted in 12 months of operations that have been free of any reactor-induced injuries to AEC contractor personnel or the public at large; no significant releases of radioactivity have occurred.

Radiological Assistance Program

During the 9 years ending December 31, 1968, the AEC received and responded to 698 requests for radiological emergency assistance. In 1968, there were 75 requests. While every incident was alleged to involve a radiation hazard, only 61 of these (1968) requests were actually associated with radioactive material. The AEC uses the personnel, equipment, and services of its facilities throughout the country to handle these requests for assistance.

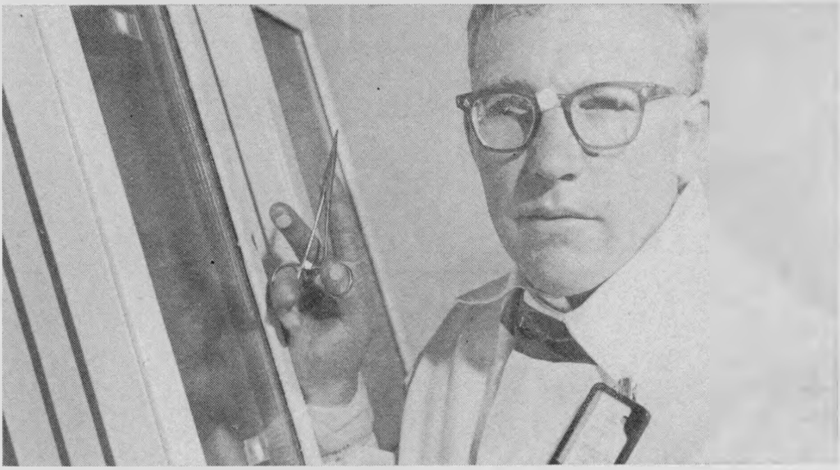
OPERATIONS SAFETY ASPECTS

A Nevada Test Site contractor, Reynolds Electrical & Engineering Co., has developed a comprehensive course on radiological emergency operations for the AEC. This course will be applied to the training of emergency teams at AEC installations, who are summoned for onsite and offsite emergencies in the event of incidents involving AEC activities; they are also summoned when needed by the AEC for emergency assistance missions under the AEC Radiological Assistance Plan. The course material, published in two manuals, is applicable to any organization that uses radioactive materials and needs to train emergency personnel.[7]

Fire Loss Management

A new film, which depicts the problems of fire protection of automatic data processing installations, was completed in 1968. The AEC's computers represent extraordinarily high-cost equipment in relatively small spaces. In addition, the stored information may be literally priceless. The film, available to the public from AEC film libraries (see footnote 1 in Chapter 13—"Informational Activities"), covers

[7] "Instructor's Manual for a Course in Radiological Emergency Operations," and "Student's Manual for a Course in Radiological Emergency Operations." Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, for $3.00 a copy.



Special Applications of Thermoluminescent Dosimeters (TLD) are being researched by the Atomic Energy Commission's Health Services Laboratory at the National Reactor Testing Station in Idaho. In the photos *above* and at *left*, more accurate radiation monitoring is obtained by taping TLD disks to the body extremities and eye glasses of NRTS personnel when they work in high probability exposure areas than with the bulky conventional film dosimeters shown clipped to the technician's collar. *Below*, a technician charts data obtained from TLD's placed inside an irradiated "human phantom" (black head and torso at *left*). The research yields accurate correlations of internal absorbed radiation dose with the actual exterior exposure.

specific fire protection measures and management control of the fire loss problem.

AEC Accidents and Property Damage

The three fatalities occurring in 1968, the fewest in any year since the beginning of the atomic energy program, resulted from construction activities. The total damage to AEC property during 1968 amounted to $597,345, approximately one-fourth of that which occurred in 1967. There were no accidents which caused more than $100,000 in property damage (Type A).[8] The greatest monetary loss in one accident was $75,000 when a fire occurred in a truck which was transporting computer equipment.

Radiation Exposure

Two Type A radiation exposures occurred in 1968. In one, an employee received an estimated exposure of 655± rem [9] to his left hand when the cover unexpectedly came off a capsule containing a radioactive source; in the other, an employee received an estimated exposure of 500–1,000 rem of soft X-ray over a small part of his right hand while working with a radiography device. Eight Type B [10] radiation exposures occurred, two whole-body, two to the skin, and four internal.

Planning Radiological Medical Care

The AEC interest in the capability of the medical profession to treat victims of radiation accidents extends to the training of licensee and contractor physicians; the facilities, staffing, and training of key physician members of community hospitals; and the extent of licensee and contractor arrangements with local hospitals to provide emergency care. The AEC intends to continue its 3-day seminars on "Planning for Medical Care and Treatment for Radiation Accident Victims." Two have been given to date, at Richland, Wash., and Upton, N.Y. Approximately 300 additional physicians will be familiarized with radiation accident problems. The seminars cover: (*a*) Diagnosis and emergency treatment of acute radiation illness;

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[8] Reportable Type A and Type B incidents are defined in TID–5360, Supplement 6, "A Summary of Industrial Accidents in USAEC Facilities, 1965–1966," available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $0.35 a copy.

[9] 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.

[10] See footnote 8.

(*b*) care of acute radiation injury, such as severe beta burn; (*c*) care of patients with internal alpha contamination whether by wound, inhalation, or ingestion; (*d*) use of chelating (radioactivity removing) agents; (*e*) general medical knowledge on hospitals' admittance of contaminated patients; and (*f*) radiation controls to limit contamination of hospitals, staff, and vehicles.

National experts in medical care related to radiation problems were joined by the staff of the AEC and by AEC-contractor personnel to provide the training.

Chapter 8

NUCLEAR ROCKET PROPULSION

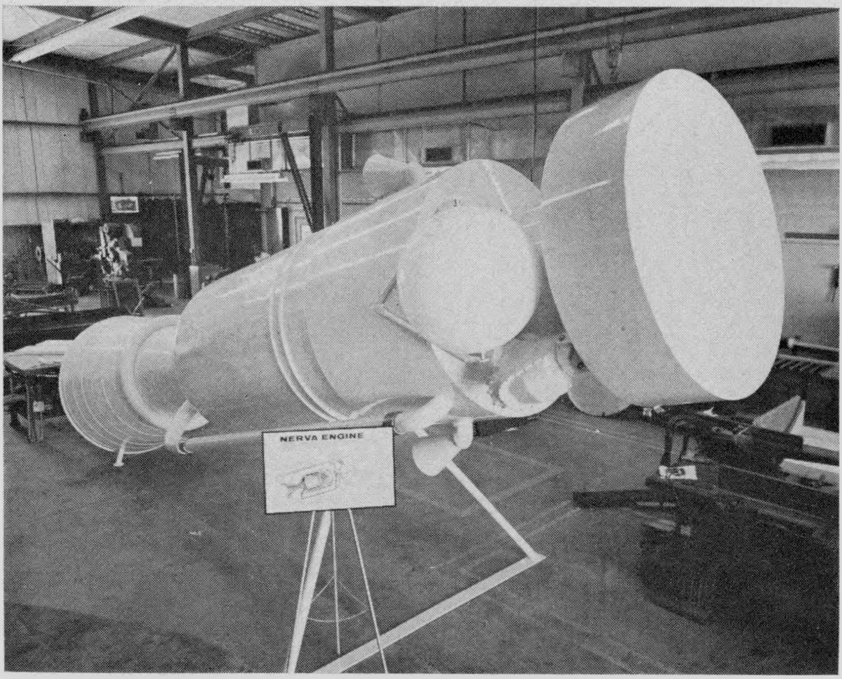
THE NERVA PROGRAM

The nuclear rocket program, a joint AEC and NASA endeavor, is aimed at providing a significant increase in propulsion capability for future space missions. The main activities in the current nuclear rocket program are: completion of the technology phase on which to base the development of a flight-rated NERVA [1] engine, the design of which is underway, and the extension of this technology to provide improvements in engine performance. In addition, effort is included to provide basic know-how for development of a nuclear stage for a space vehicle.

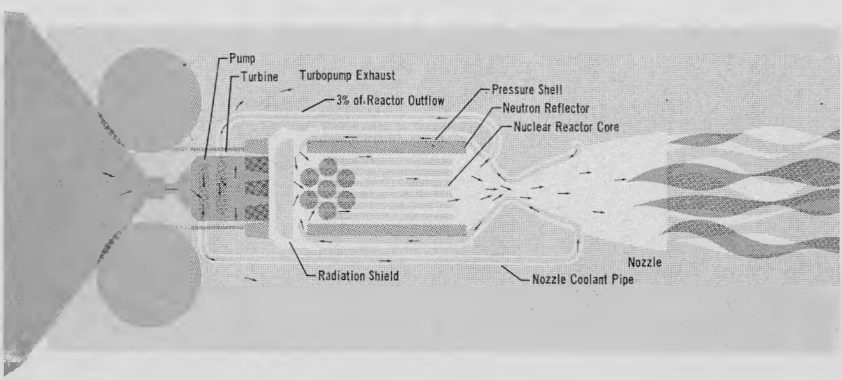
The NERVA nuclear rocket engine for flight applications has a thrust rating of 75,000 pounds. Preliminary mission studies show that an engine of this size can perform most of the advanced missions currently being considered in NASA planning. The NERVA engine achieves its propulsion capability by heating liquid hydrogen from −420° F. to over 4,000° F. in a compact reactor powerplant; the hydrogen's tremendous expansion through the rocket nozzle produces the propulsive thrust. Years of extensive research and technology development have shown how to make a flight-weight system operate under these severe conditions successfully.

One task remains in the NERVA technology effort: full testing of a complete nuclear rocket engine system—called the Experimental Engine (XE)—in the new Engine Test Stand (ETS–1) at the Nuclear Rocket Development Station (NRDS) in Nevada. Other activities of a technology nature have the goal of extending the performance capability of nuclear rockets. For example, ways are being sought to heat hydrogen to temperatures above 5,000° F. in reactors that will operate for several hours with high reliability and with the ability to stop and start many times. While not essential for a successful

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



A Gleaming White 24-Foot Model of the NERVA nuclear rocket engine is shown *above* in the general shops area at the Nuclear Rocket Development Station in Nevada, just before shipment to Mexico City. The engine was displayed in an exhibit sponsored by the AEC as a part of the XIXth Olympiad culture program there. Diagram *below* shows the principle of the NERVA engine. The liquid hydrogen (—420° F.) flowing (from tanks at *left*) through and around a nuclear reactor (*center*) is heated to 4,000° F. and forced, as a gas, from the nozzle (at *right*) to provide propulsive thrust. The reactor, when fully developed will be about the size of an office desk.



NERVA development, this advanced research aims at the ultimate in performance for solid-core nuclear rockets and would permit full realization of the mission potential for nuclear propulsion.

PROGRESS IN NERVA DEVELOPMENT

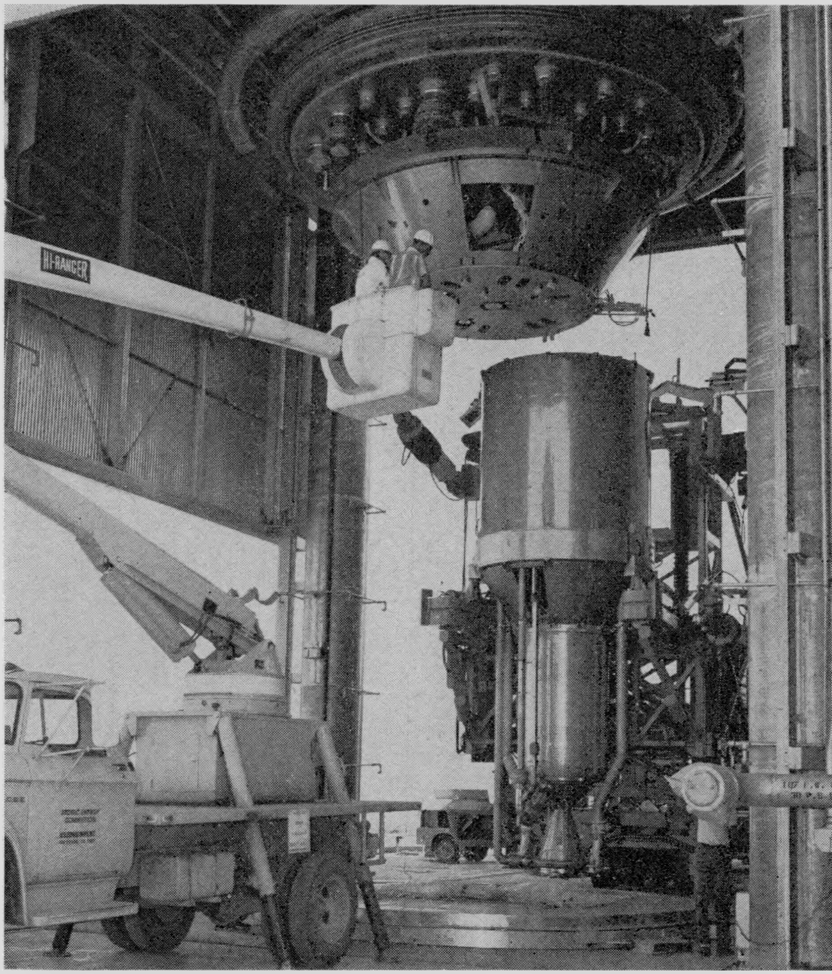
Programs which provide basic technology usually have general goals or objectives; the development of systems for space flight missions requires a clear statement of requirements. Therefore, the first step in NERVA development has been to determine engine requirements from a detailed definition of likely missions and to document all studies and decisions that pertain to the process of determining requirements. In addition to thrust level, temperature, and operating time, it is necessary to specify, for example, the loads imposed on the NERVA engine during booster flight, the reliability and safety goals, the location for assembly of the complete flight system, the type of pre-launch check-out, and the many other details which can have an influence on the final engine configuration.

After initial requirements were established, studies of several design alternatives began as part of the process of engine design. As design progresses, problems are sometimes uncovered and new opportunities are revealed which may alter the mission plans or signify a change in the requirements to the benefit of the project. Requirements also change as more is learned about missions and launch vehicles that will use the NERVA engine. This give and take process is now underway in the preliminary design phase of NERVA development.

Progress in Nuclear Rocket Technology

The principal interest in the program during 1968 was on the completion of the base of data, information, and experience required for NERVA development. Highlighting the accomplishments of the year in this area were the completion of tests on the ground-experimental, cold-flow [2] engine (XECF), the high-power Phoebus–2A reactor, and the small Pewee–1 reactor; and, the initiation of tests on the ground-experimental "hot" [2] engine (XE). The XECF and XE engine experiments were conducted by Aerojet-General Corp. and Westinghouse Electric Corp., the industrial contractor team responsible for NERVA development. The Phoebus–2A and Pewee–1 reactor tests were conducted by the Los Alamos Scientific Laboratory as a part of

[2] A "cold-flow" assembly cannot become radioactive since there is no uranium in the core; a "hot" reactor becomes radioactive during operation since it is uranium-fueled.



The First Ground Experimental Nuclear Rocket Engine (XE) assembly, a "cold flow" configuration, is shown being installed in Engine Test Stand No. 1 at the Nuclear Rocket Development Station in Nevada. Functionally, the XECF engine is similar to the "breadboard" nuclear engine system (NRX/EST) tested in 1966, except that the experimental engine more closely resembles flight configuration. The XECF has two major subassemblies: an "upper thrust module" (containing propellant feed system components) and a "lower thrust module" (reactor and nozzle assembly). These two modules, each of different diameters, are shown attached and being moved into place as one unit. The two-module arrangement facilitates remote removal and replacement of major subassemblies in the event of a malfunction. The "cold flow" experimental engine was used for a series of tests to verify that the recently completed test stand was ready for "hot" (radioactive) engine testing; investigate engine startup under simulated altitude conditions; and the checking of operating procedures not previously demonstrated. "Cold flow" experiments are conducted using an assembly identical to the design used in power tests except that the cold assembly does not contain any fissionable material and no power is generated.

the supporting and advanced technology effort. Important contributions also were made in fuel-element materials research and tests at Los Alamos, the Westinghouse Astronuclear Laboratory (Pittsburgh, Pa.), and the AEC's Y–12 Plant at Oak Ridge, Tenn. This research will form the basis for establishing the fuel-element specifications for the future series of reactors to be tested in the NERVA development program.

Phoebus–2A Reactor Program

The Phoebus–2 program culminated in the power testing of the Phoebus–2A reactor in mid-1968. The decision to build and test the Phoebus–2 reactor had been made in 1963 to provide technology for high-power, high-temperature rocket reactors. Originally, the Phoebus–2 reactor was not planned for a specific engine application; subsequently, however, serious thought was given for a time to the development of a high-thrust (200,000 pounds) NERVA engine based on this reactor design. When a 75,000-pound-thrust rating was selected for the NERVA engine, the Phoebus–2 program continued toward its original technology goals. In addition, certain detailed design features of the Phoebus–2A reactor had become likely candidates for the NERVA engine, and, therefore, results of testing the reactor would have direct benefits for the NERVA development program.

The major experiment of the Phoebus–2A test program was conducted on June 26, 1968, when the reactor was operated for a total test time of approximately 32 minutes; about 12 minutes were at a power level above 4,000 megawatts (Mw.), with 4,200 Mw. the peak power level. At a number of times during the run, experiments were carried out in which propellant flow through the reactor and reactor power were varied to determine the response of the reactor system. Good data, applicable to the planned NERVA flight reactor, were obtained about the control of high power-density nuclear rocket reactors.

On July 18, the Phoebus–2A was restarted to conduct a series of experiments at low- and intermediate-power levels. The reactor was operated over a wide range of power levels up to about 3,700 Mw. and for a total test time of approximately 30 minutes. The experiments gave added data on the nuclear and thermal characteristics of high-power-density reactors. These data also will be very useful in the development of the NERVA flight reactor.

In addition to Los Alamos, other major contributors to the Phoebus–2A test included Aerojet-General (Sacramento, Calif.) which developed and fabricated the exhaust nozzle, and the Rocketdyne Division

(Canoga Park, Calif.) of North American Rockewell which developed the facility turbopumps for the liquid hydrogen (LH_2) propellant feed system. When the Phoebus-2A reactor reached 4,200 Mw. on June 26, the LH_2 feed system was pumping at a flow rate of 27,500 gallons-per-minute.

Fuel Element Materials Research

The full-scale reactor tests that are conducted at NRDS are the culmination of many diverse research and development activities. One of the most significant of these activities is the work being conducted by Los Alamos, Westinghouse, and the Y-12 Plant to improve the performance and duration capability of nuclear rocket reactor fuel elements.

The initial duration objective for nuclear rocket fuel elements was achieved in December 1967 when the NRX–A6 reactor was operated for 60 minutes at full power (approximately 1,100 Mw.). During 1968, laboratory tests for improving fuel elements provided test durations of more than 100 minutes. The environmental conditions for these tests were much more rigorous than the conditions achieved in the NRX–A6 reactor. The emphasis in fuel element materials now has shifted toward cyclic testing and testing of higher power densities and temperatures.

Pewee Reactor Program

The laboratory programs for improving fuel element performance use electrically-heated corrosion furnaces for corrosion testing. However, the progress made using this method of testing must be checked periodically through reactor tests at NRDS. Investigations at Los Alamos indicated that a smaller-sized reactor, requiring fewer fuel elements, would be an economical approach to satisfying this requirement. As a result, the design and fabrication of two such reactors, the Pewee–1 and Pewee–2, was initiated.

During 1968, a test cell at NRDS was modified to meet the requirements for Pewee reactor testing, and power tests of the Pewee–1 reactor were completed. The test cell modifications consisted primarily of the addition of a new liquid-hydrogen, feed-system turbopump and minor changes to various lines and valves to accommodate the reduced flow requirements for Pewee reactor testing.

The major experiment of the Pewee–1 test program was conducted on December 4. During this experiment, the reactor was operated at significant power levels for about one hour and a half. More than 40 minutes of the operation was conducted during two separate cycles at power levels over 500 megawatts, about half the power of previous Kiwi and NERVA technology reactors. The reactor operated in a stable fashion and achieved a temperature of 4,140° F., the highest operating temperature yet achieved in the nuclear rocket program. The December 4 test was the second power operation of the Pewee–1; the first was conducted on November 21 at partial power for 40 minutes to determine the overall operating characteristics of the Pewee reactor design.

XE Engine Test Program

The last activity in the NERVA technology program before all NERVA contract effort is devoted completely to development, is the testing of the ground-experimental engine, the XE engine. The components of the XE engine are arranged to closely approximate a flight engine system. Earlier in the NERVA technology program (1966), a "breadboard" engine—consisting of similar components arranged for convenience on a reactor test car—was tested in the first time demonstration operation of a nuclear rocket engine as a self-contained powerplant. The breadboard engine was tested with the exhaust nozzle pointing upward, as in previous reactor tests with the hot-hydrogen exhaust expelled directly into the atmosphere.

The XE engine is designed to be tested in the down-firing position and under simulated altitude conditions to approximate the operation of an engine in flight. Engine Test Stand No. 1 (ETS–1), the new down-firing test stand[3] at NRDS, provides these test capabilities. Checkout of the ETS–1 was accomplished in April of this year using a cold-flow version of the XE engine called the XECF. The XECF engine also was used to investigate engine startup in the test stand, to check engine and stand operating procedures, and to investigate engine malfunctions under simulated altitude conditions. The engine and stand operated as planned, and the test results produced the basis for proceeding with "hot" tests of the engine in the stand later in the year.

The XE engine was installed in the stand on October 25, 1968, and a series of preliminary checks and tests were conducted to assure that the engine and stand were ready for operation. These preliminary activities culminated on December 4, with the completion of the first engine experiments, an initial criticality check and calibration run, in the XE test program. Power testing of the XE engine will be conducted during the first half of 1969.

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[3] See p. 167, "Annual Report to Congress for 1967."

Chapter 9

SPECIALIZED NUCLEAR POWER

SPACE ELECTRIC POWER

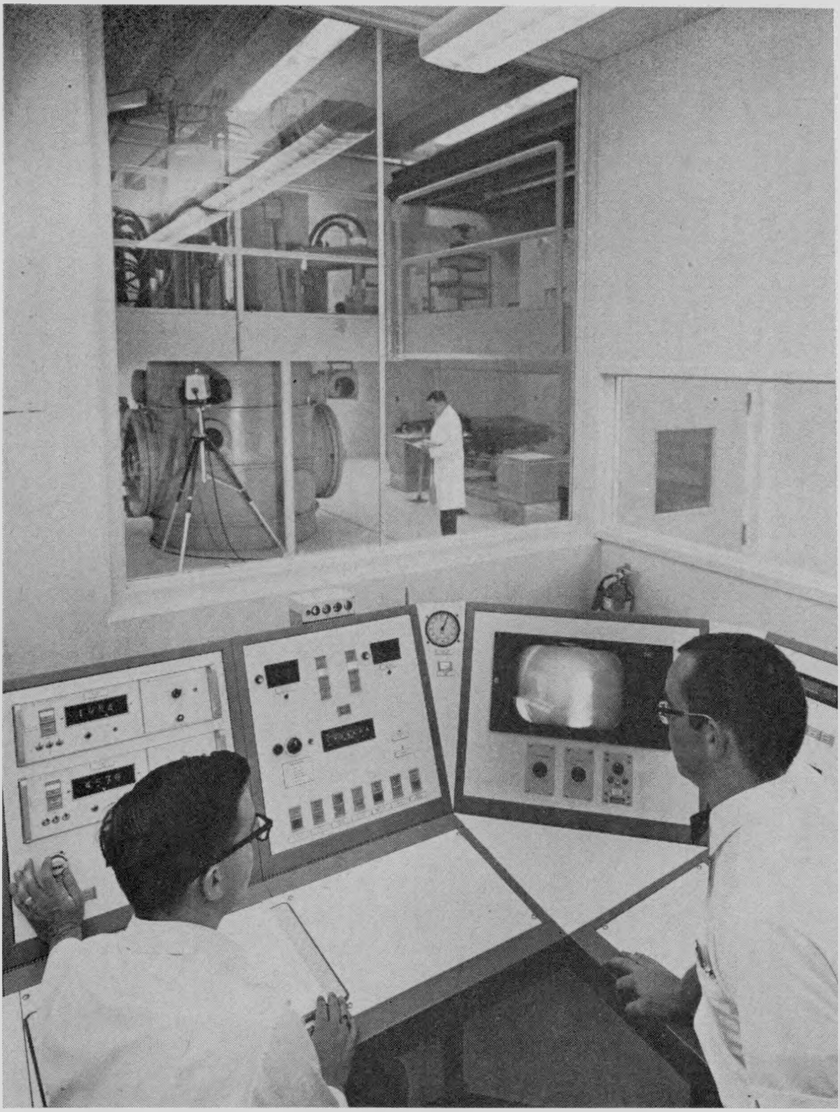
In 1968, development of nuclear power for spacecraft included continuation of work on system technology that will be required in future missions as well as on several operational systems for current national space program missions. Development of five SNAP–27 [1] generators was completed except for final qualification testing. The generators are to be delivered to the National Aeronautics and Space Administration (NASA) for use in future lunar (Apollo) missions. A SNAP–19 generator system was on the Nimbus B satellite which fell into the Pacific Ocean when the launching was aborted because of booster malfunction; the fuel was recovered after an underwater search and a replacement unit is scheduled for launch with a replacement Nimbus B in 1969. In the higher power area, NASA studies explored the use of reactor power systems on the operational space stations of the 1970's.

SPACE ELECTRIC POWER TECHNOLOGY

Reliable onboard electrical power for spacecraft is vital to the success of all space missions. Nuclear power systems will be needed for long-lived missions on the moon (where nights last 350 hours), or if the spacecraft must be invulnerable to existing and man-enhanced radiation belts, or for travel to the distant planets where low atmospheric drag is a problem, or for power requirements of tens of kilowatts or above.

The potential of space nuclear systems is enormous—if tough technical problems can be solved to improve performance and to assure safety of advanced systems. Once developed, this technology will bene-

[1] SNAP—Systems for Nuclear Auxiliary Power.



The High Enthalpy Arc Tunnel (Heat) began operation at Sandia Laboratories during 1968. It is the Nation's largest plasma arc chamber and was designed for radioactive materials testing in the AEC's aerospace nuclear safety program. The chamber recreates the fiery environment encountered by space objects as they enter the earth's atmosphere at 400,000 feet at a speed of 24,000 miles per hour. For up to 30 minutes of operation, the HEAT can produce 20,000° F. from a power input of 5 million volts. Shown above are the chamber in the background and the readout console with its video display tube. Test information is relayed to a 200-channel computer recording system at the rate of 10 times a second. These data together with examination of the test models enable researchers to evaluate reentry effects upon materials and shapes.

fit potential users in space, terrestrial, oceanographic, and commercial "spinoff" applications.

The nuclear systems for possible future space missions already established, or foreseen, and the common technology requirements of the isotope and reactor units, are shown in Table 1. The limits of each category are not exact; however, the indicated differences among the categories establish the problems which must be solved in each. In most cases, pilot model systems will be developed to serve as building blocks over each range, avoiding having to tailor a system to each future need.

The AEC program is directed toward acquiring the technology needed for each of these categories, as well as producing flight systems specifically requested by user agencies.

Reactors for Space

Zirconium Hydride Reactor Systems

Testing of a second-generation uranium-zirconium hydride reactor (S8DR) began in 1968 at Santa Susana, Calif., by Atomics International. This reactor is based on the technology successfully demonstrated in the SNAP–10A program in 1965, and further investigated with tests of the SNAP–8 experimental reactor. It will demonstrate

TABLE 1.—CATEGORIES OF NUCLEAR SYSTEMS AND TECHNOLOGY

Category	System characteristics	Established systems	Principal technology goals
0–100 Watts (W)	Self-contained isotope-thermo-electric (TE).	SNAP 3A, 9A, 19, 27.	Increase fuel and capsule temperature.
100–1,000 W	Modular isotope TE.		Increase power conversion efficiency.
a. Short Life (2-5 Mos.)	Short half-life.		
b. Long Life	Reusable fuel and/or higher efficiency power conversion.		Increase TE life.
1–10 Kilowatts (Kw) a. Recoverable fuel.	Modular, reusable isotopes and high-efficiency power conversion.		Reduce power conversion system weight.
b. Unrecovered fuel, unmanned.	Partly shielded reactor.	SNAP 10A.	Develop higher temperature to reduce specific weight and radiator area.
10–100 Kw	Reactor-TE (10–25 Kw).		Develop more efficient power conversion.
	Reactor-Rankine (25–100 Kw).		
100 Kw and above	Reactor-Thermionic or reactor Rankine.		Increase power conversion system life.

startups and continuous operation at design conditions of 1,300° F. outlet temperature and 600 thermal kilowatts (kwt.). Reactors of this type can be mated with either mercury Rankine cycle [2] power machinery or with thermoelectric converters to produce electrical power in space up to 100 kwe.

A power system using the zirconium hydride reactor and the so-called "compact" thermoelectric converter being developed for the AEC by the Westinghouse Astronuclear Laboratory, Large, Pa., was studied during 1968 with the objective of defining subsystem development needs and mission integration requirements. Atomics International, Canoga Park, Calif., and NASA's Marshall Space Flight Center, Huntsville, Ala., studied the possible use of this system on manned-orbiting stations. The system offers an essentially static powerplant of high reliability and efficiency for use in the 1970's, at power levels of 20 to 25 kwe.

Thermionic Reactor

The incore thermionic [3] reactor research program continued to emphasize the development of fuel elements capable of long endurance operation at emitter temperatures above 3,000° F. A protoype thermionic diode was operated in a reactor core for more than 1,700 hours (71 days). Reactor and fuel element development is being carried out by Gulf General Atomic, San Diego, Calif., and the General Electric Co., near Pleasanton, Calif. Supporting technology is being conducted at Thermo Electron Corp., Waltham, Mass., and at the Los Alamos Scientific Laboratory (LASL).

During 1968, LASL studied a reactor using the SNAP–8 type uranium-zirconium hydride (UZrH) elements in which thermionic converter rods were inserted in place of some of the hydride rods of the SNAP–8 reactor. This approach resulted in a static system capable of 20 to 100 kwe. output in low-weight systems. The concept uses the well-developed SNAP–8 reactor technology with the advanced thermionic heat-to-electricity conversion method.

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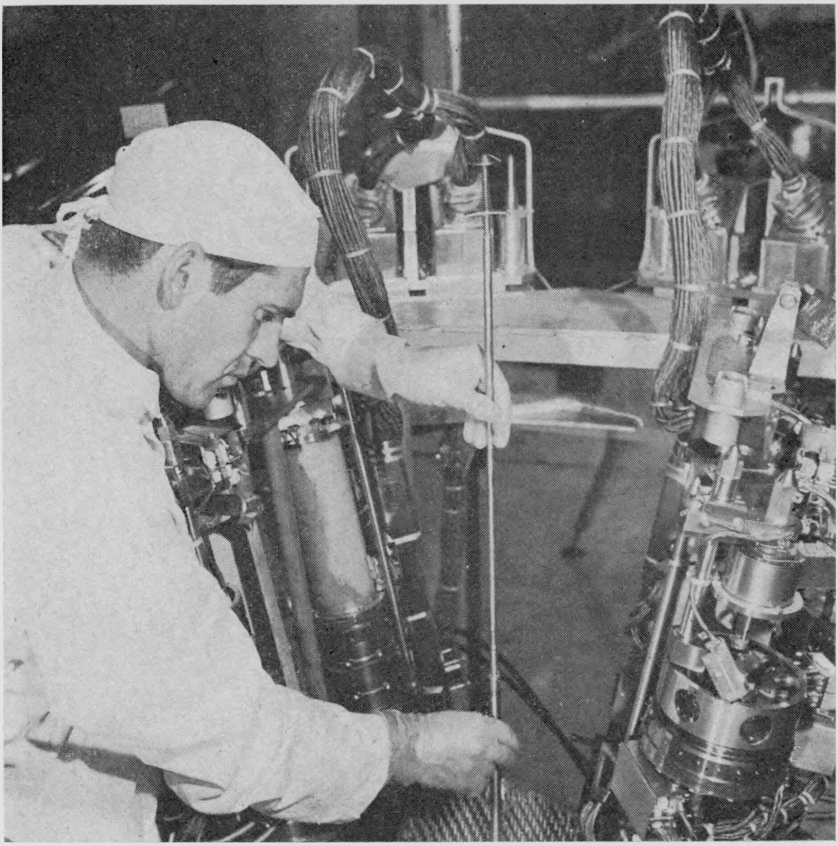
[2] Rankine cycle—The Rankine Power conversion is a method of converting heat to mechanical energy using a two-phase (boiling and condensing) working fluid cycle. For space power systems, the reactor coolant liquid takes heat from the reactor core and conveys it to a heat-exchange boiler where the liquid-metal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

[3] 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. This generation of electricity may take place within the reactor core.

Advanced Liquid-Metal-Cooled Reactor

Lawrence Radiation Laboratory, Livermore, completed reference design studies of high performance liquid-metal-cooled space power reactors in the thermal power range of 600 kw. to 60 megawatts. This



Prototype of Compact Nuclear Reactors which may one day supply power on the moon or aboard spacecraft, the SNAP–8DR is undergoing ground tests at the Santa Susana Nuclear Field Laboratory of Atomics International (AI). It uses much of the technology of the SNAP–10A, a compact reactor system which, in 1965, became the first nuclear reactor to operate in earth orbit, and was similarly built by AI for the AEC. For its design potential as a power source for lunar missions, earth orbiting laboratories and deep space voyages, the reactor system offers long life without the need for refueling and maintenance. At full power operation, it is designed to produce 600 kw. of thermal energy. Photo shows a technician inserting one of 211 fuel elements into the core vessel during initial criticality experiments. SNAP stands for Systems for Nuclear Auxiliary Power.

reactor concept is primarily for use with potassium Rankine [4] conversion, although it may also be used with Brayton,[4] thermoelectric, and MHD [4] conversion. The design studies also included heat pipe-cooled reactors for use with out-of-core thermionics.These studies were made to establish technology objectives for space power reactors that would be used operationally in the mid-1980's, and beyond.

Initial test results were obtained from a carefully structured research and technology program centered on uranium nitride fuel, tungsten alloy cladding and lithium reactor coolant. Among the more prominent tests were fuel irradiations conducted at 2,732° F. and a lithium/tungsten compatibility demonstration conducted in a unique "pumped capsule" at 2,552° F. This capsule was developed at LRL, Livermore, to provide pumped liquid metal circulation in a compact unit, permitting a relatively large number of tests at reasonable cost.

Continuation of the liquid metal cooled reactor program was not authorized by Congress during 1968; accordingly, the project is now phased out.

Isotopic Power Systems for Space

Various combinations of radioisotope heat sources and electrical generator concepts may be used for space electric power systems. In the present concepts, the two isotopes of major interest are plutonium-238 (half-life, 87 years) for long-lived systems and polonium-210 (half-life, 138 days) for short-lived systems with curium-244 (about 18 years) and other isotopes under consideration for the future. Electricity is generated by thermocouples,[5] with thermionics and a noble gas-driven turbine-alternator cycle as developmental concepts.

SNAP–3 in Eighth Year

On June 29, 1968, a SNAP–3 unit—the first such isotopic generator to be orbited—entered its eighth year of operation in space, more than 2 years beyond its 5-year design life expectancy.

This radioisotope—thermoelectric generaor concept—that uses plutonium-238 as a "fuel"—has been in operation in space since the first

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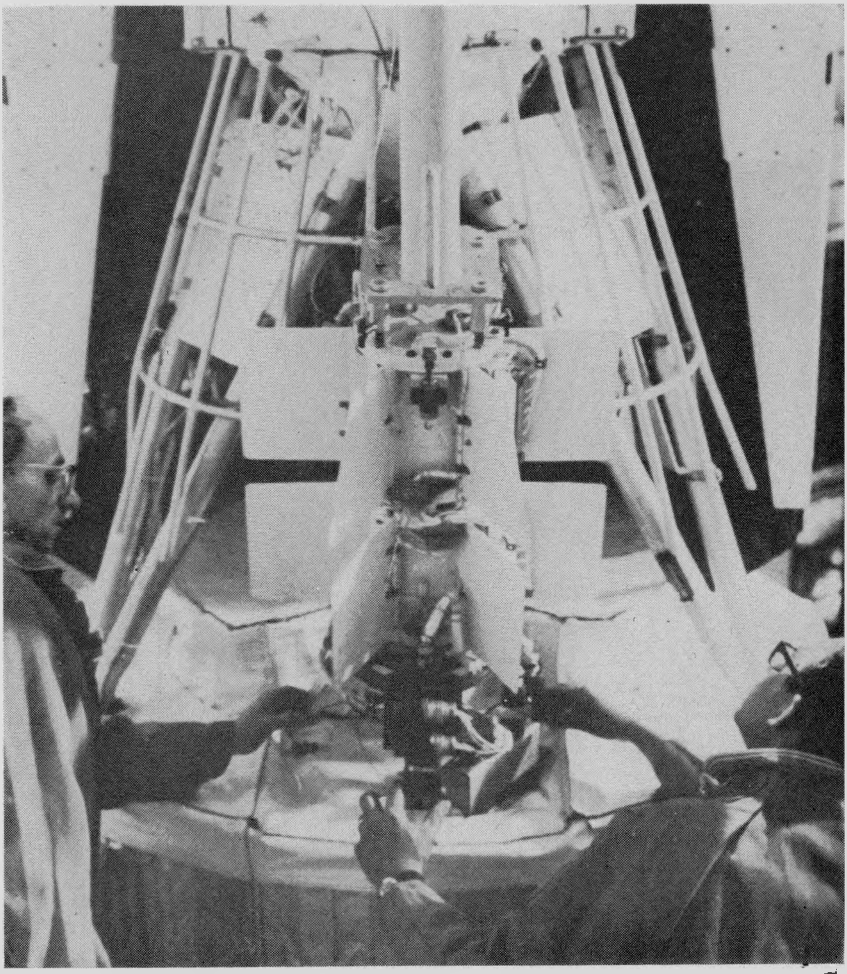
[4] Rankine cycle power systems employ a working fluid-like steam—which evaporates and recondenses during each pass through the system. In the Brayton cycle, a non-condensing gas serves the same purpose. MHD power conversion systems extract energy from a moving fluid by causing it to interact with an electromagnetic fluid.

[5] Thermocouple—A thermocouple is made up of two dissimilar materials joined together at both ends by an electrical circuit, producing a loop in which an electric current will flow when there is a difference in temperature between the two junctions.

SNAP–3 power system was launched aboard a navigation satellite in 1961.

Two SNAP–3 units, at 2.8 electrical watts, and two SNAP–9A units (launched in 1963), at 25 electrical watts, have been used in space vehicles. SNAP–3 and SNAP–9A were developed by the Martin-



Two SNAP–19 Generators, which provided about 50 watts of electrical power, are shown being positioned by technicians on board the NASA Nimbus–B weather spacecraft prior to the aborted May 18, 1968, launch. The SNAP–19 generators, which require no moving parts, convert the heat supplied by the plutonium-238 isotope to electricity by use of thermoelectric elements. Each generator weighs about 28.5 pounds and is required to operate in space for a minimum of 1 year. The Nimbus–B launch was aborted by the range safety officer because of a launch vehicle malfunction, the two SNAP–19 capsules were recovered from the Pacific Ocean. A replacement Nimbus–B will be launched in 1969.

Marietta Co., Baltimore, Md. The plutonium-238 heat sources for the SNAP–3 and SNAP–9A were developed and fabricated at the AEC's Mound Laboratory, Miamisburg, Ohio.

SNAP–19 Recovery

On May 18, 1968, the NASA Thorad-Agena-D vehicle, which was to carry the Nimbus-B weather satellite and its SNAP–19 isotope generators into orbit, was destroyed off the coast of California because of a vehicle guidance system malfunction, soon after launching. The submerged satellite was detected after an underwater search, and the two valuable plutonium-238 capsules were recovered. The capsules suffered no apparent damage. Previous testing had established the nuclear safety attributes of the isotopic fuel in the event of ocean submergency.

The Nimbus-B weather satellite mission has been reprogrammed by NASA and will again use SNAP–19 isotope generators to provide supplementary power. Launch is scheduled for spring of 1969.

SNAP–27 for Lunar Landing

The SNAP–27 fueled with plutonium-238, being developed for the AEC by the General Electric Missile and Space Division, Valley Forge, Pa., will provide at least 63 watts of power to an unmanned scientific experiment station for at least one year after being placed on the moon by astronauts during Apollo (moon landing) missions. Using the SNAP–27 nuclear power supply, the Apollo Lunar Surface Experiments Package (ALSEP)[6] is capable of obtaining and transmitting scientific data, even during the 350-hour lunar night.

The SNAP–27 lunar surface generators were delivered to NASA during the second half of 1968. Over 25,000 ground-test hours have been logged by three generators to demonstrate the long-term power-producing capabilities of the SNAP–27 thermoelectric conversion system.

Table 2 lists the SNAP isotopic power systems already orbiting or planned for space use. (Development of heat sources for these systems is described in the "Isotopic Fuels Development" section of this chapter.)

Polonium-Fueled SNAP–29

The SNAP–29 ground test generator being developed for the AEC by the Nuclear Systems Division, Isotopes, Inc., Middle River, Md., is to be fueled with polonium-210. It is designed to provide 400 watts of

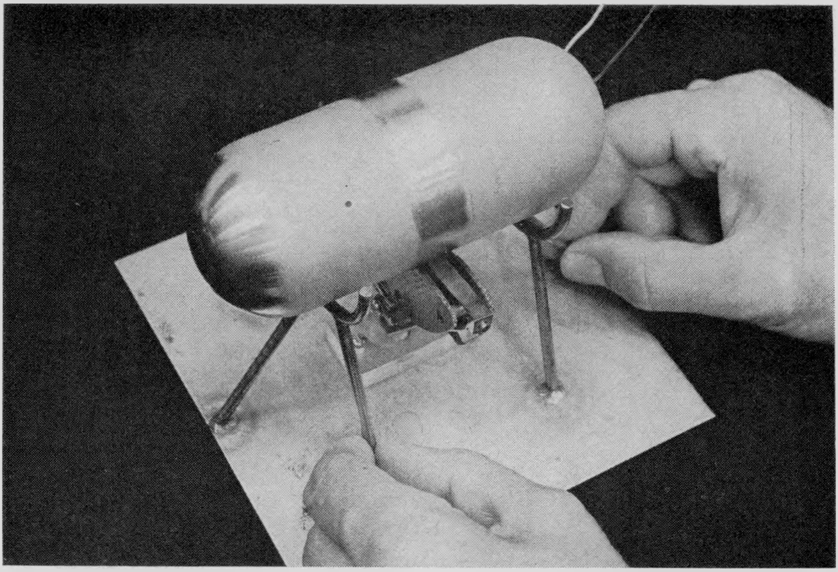
[6] See pp. 205–206, "Annual Report to Congress for 1966" and pp. 174–175, "Annual Report to Congress for 1967."

electrical power for 3 months, in its primary manned or unmanned space flight mission application; but the basic 200-watt modules are capable of being used in systems of from 200 to 1,000 watts. Thermoelectric conversion subsystems, heat transfer units using heat pipes, and the fabrication and test of the heat source components are under devel-

TABLE 2.—SNAP ISOTOPIC POWER SYSTEMS FOR SPACE

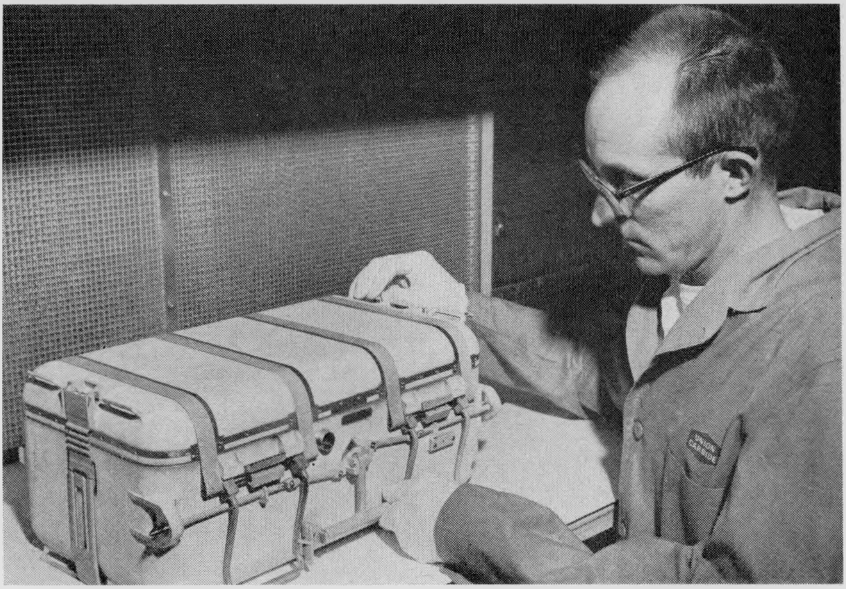
Designation (SNAP No.)	Prime contractor	Net electric power (watts)	Application	Fuel	Unit design life	Status
3	Martin-Marietta Co.	2.7	Navigational satellites (DOD).	Pu^{238}	5 years	Unit launched in June 1961 is still operating in orbit, quantitative performance data not available.
9A	Martin-Marietta Co.	25	Navigational satellites (DOD).	Pu^{238}	5 years	Units launched in Sept. and Dec. 1963 are still operating but at a lower power level. Satellites inoperative.
11	Martin-Marietta Co.	25	Moon probe (NASA).	Cm^{242}	90 days	First fueling of a generator with curium-242 accomplished in July 1966. In Oct. 1966 fueled unit completed 90-day test under simulated lunar conditions.
19	Isotopes, Inc.*	25	Nimbus-B Weather satellite (NASA) (One, 2-module 50-watt system per satellite.)	Pu^{238}	1 year	Launch aborted May 1968 due to vehicle failure. Fuel recovered. Replacement unit delivered Dec. 1968.
27	General Electric.	50	Apollo Lunar Surface Experiments Package (ALSEP) (NASA) power for experiments placed on the moon by Apollo astronauts.	Pu^{238}	1 year	5 SNAP-27 generators delivered to NASA in 1968 for Apollo flights and follow-on missions.
29	Isotopes, Inc.*	200-1,000	Possible manned and unmanned space applications (DOD and NASA).	Po^{210}	3 months	400 watt prototype ground demonstration scheduled for fiscal year 1970. Fabrication and testing of critical materials and components underway.
Radioisotope Brayton.	(Not yet selected.)	5,500	Manned space missions.	Pu^{238}	1 year	AEC will develop heat sources; NASA the Brayton cycle. Fuel capsule development and testing underway.
Transit Power Supply.	TRW Systems Group.	20	Navy Navigational Satellites.	Pu^{238}	5 years	Detailed design and subcomponent development initiated.

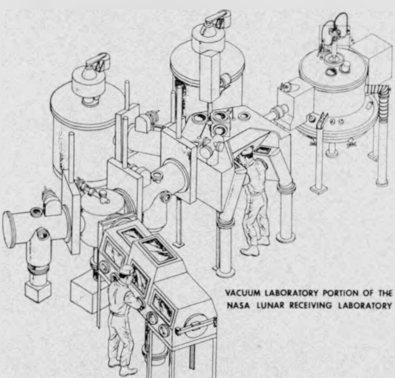
*Isotopes, Inc. purchased Martin-Marietta Nuclear Division, August 1968.



SNAP–19B Intact Reentry Heat Sources (*IRHS*) are being fabricated at Mound Laboratory to power the nuclear generators for the Nimbus–B advanced weather satellite. Photo *above* shows one such capsule, approximately 2 inches in diameter by 6 inches long, being prepared for surface temperature measurements prior to assembly. Design criteria now require intact reentry of some isotopic fuel capsules and impact burial into the earth's surface. Sandia Laboratories has conducted safety studies which involve the responses of capsules to impact, soil penetration, and their chemical and thermal interactions with soils. Since an intact isotopic generator continues to produce heat after impact and burial, the capsule and/or soil may melt and corrosion rates will increase. Illustrated *below* are the sintered soil masses and corrosion, that resulted from burial tests of a SNAP–27 plutonium-fueled capsule—temperatures attained by the capsule exceeded 2,550° F.

opment. A ground demonstration of an electrically heated prototype flight system is planned for fiscal 1970.





Special Vacuum Containers are being fabricated by the Oak Ridge Y–12 Plant for the National Aeronautics and Space Administration. The aluminum containers (*above*) will be used by Apollo astronauts to transport lunar specimens back to earth. When the geological samples from the moon are received on earth, they will be examined initially in the special vacuum laboratory (drawing at *left*) located in NASA's Lunar Receiving Laboratory at Houston. The facility was designed and fabricated by the Oak Ridge Y–12 Plant. The containers for the samples are cleaned, sterilized, and dried in the glove box in the left foreground, then opened in the glove box (center photo) and the samples removed. At far right is the ultra-high vacuum chamber in which high integrity samples will be removed from vacuum canisters. A tool storage carrousel is at left rear, and the sample storage carrousel at right rear. The Oak Ridge Y–12 Plant is operated by Union Carbide Corp. for the AEC.

TERRESTRIAL ISOTOPIC POWER

The AEC is pursuing the orderly development of long-lived radioisotope power systems for use in the terrestrial and marine environments. With regard to the latter, a 1968 report said ". . . perhaps the most critical, unmet need of underwater technology is for inexpensive power sources with longer endurance. Today, nearly all underwater missions, except for military nuclear submarines, are limited by the low capacities of available batteries. . . ."[7]

The unique characteristics of radioisotope devices make it possible to meet a large portion of critical requirements in activities involving underwater surveillance; sonar; weather buoys; navigational aids; seismic stations; weapons systems; manned undersea platforms and commercial exploitation.

Studies and experiments have focused attention upon the advantages of radioisotope power sources over alternate power sources and have identified performance characteristics and design criteria which the AEC is using to guide its research and development efforts.

The initial effort on the part of the AEC in terrestrial radioisotope power development centered upon the design and development of the first generation SNAP–7 series of strontium-90-fueled devices. These proof-of-principle devices were operationally tested under a multitude of environmental conditions ranging from the Antarctic to the bottom of the Atlantic Ocean.

The SNAP–7 program, which was completed in 1966, demonstrated the feasibility of developing long-lived strontium-90 power sources capable of safe and unattended operation.

Second Generation Radioisotope Power Sources

As an outgrowth of the SNAP–7 program, the AEC initiated development of a second generation of radioisotope power sources in the 10 to 100 watt power range. Structurally sound thermoelectric converters have been built in this power range with stable operation at relatively high temperatures; *e.g.*, 1,000 to 1,000° F. End-of-life efficiencies of 8.0 to 8.5 percent have been achieved. Through the application of extensive quality assurance techniques, reliability and reproducibility of these devices are being demonstrated.

The present effort consists of two projects—SNAP–21 and SNAP–23.

[7] "Marine Science Affairs—A year of Plans and Progress, the Second Report of the President of the Congress on Marine Resources and Engineering Development," March 1968. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, price $1.

SNAP–21 and –23 Projects

The SNAP–21 project objective is to develop a series of compact strontium-90 power sources, 10- and 20-watt units of common design and technology, for general purpose deep-sea and ocean bottom application. Design and development effort has been successfully completed, and hardware development and test is underway. The 10-watt units are undergoing final fabrication and assembly and the first fueled prototypes will be ocean-tested off San Clemente Island, Calif., early in 1969. The Minnesota Mining and Manufacturing (3M) Co., St. Paul, Minn., has prime responsibility for this program.

SNAP–23 involves the development of a series of economically-attractive strontium-90 power sources. Power sources of common design and technology in the 25-, 60-, and 100-watt range will be developed and environmentally tested. In 1968, the first electrically heated 60-watt system was constructed and successfully placed on test. This program is being jointly managed by the 3M Co. and Westinghouse Astronuclear Laboratory.

Large Isotope Kilowatt Systems

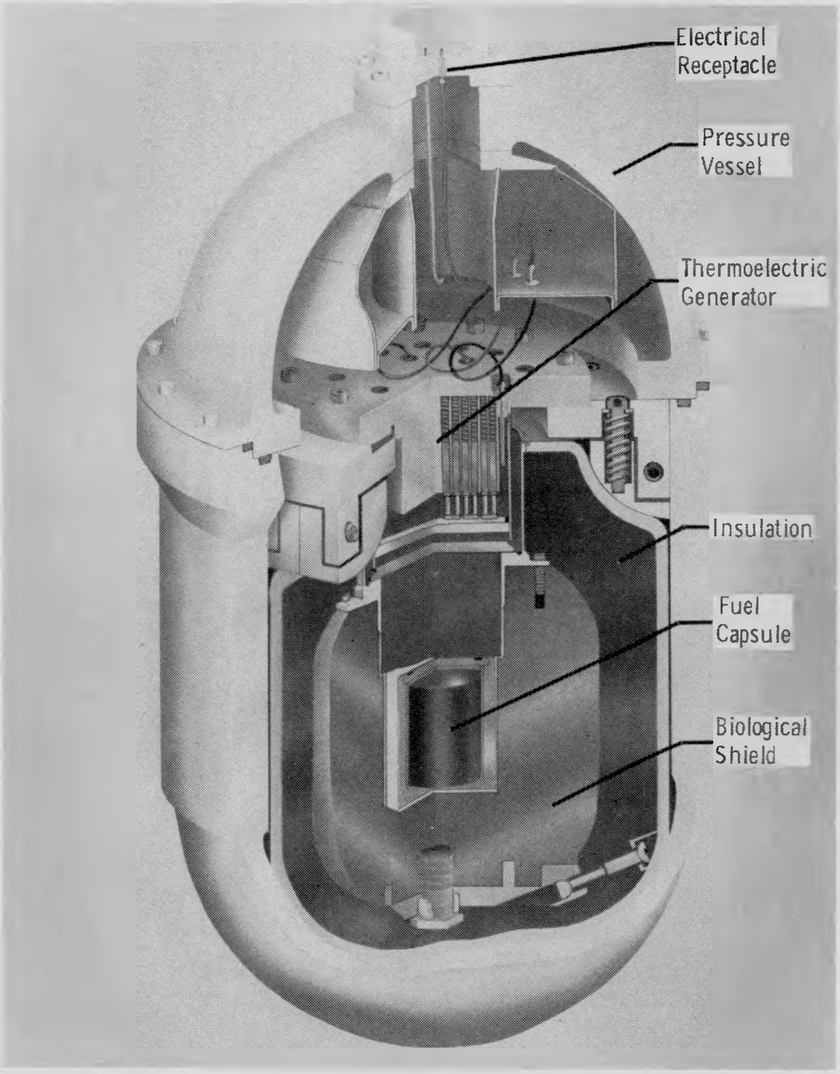
Studies by the Department of Defense and the National Research Council of the National Academy of Sciences have identified prospective applications of critical importance to the national defense for large radioisotope power sources, in the 1 to 10 kw range, for use in the ocean, and have resulted in recommendations that AEC undertake the development of these power sources on a priority basis.

In 1968, limited design and engineering studies were conducted at Oak Ridge National Laboratory. These studies involved radioisotope fuel selection, shielding studies, and energy conversion technology. Further study of large systems is continuing. Basic research and development will be initiated in 1970.

Nuclear Powered Cardiac Pacemaker

A surgically-implantable plutonium-fueled cardiac pacemaker can provide important improvements in certain areas of medical capability such as cardiac stimulation required in the treatment of "heart-block," a relatively common cardiac affliction. The intrinsic characteristics of radioisotope devices will, in these applications, result in a significant increase in the useful lifetime from the 1½ to 2 years present battery capability, to 10 years or more with a nuclear power source.

During the past 2 years, important progress was made toward the development of a nuclear pacemaker. Models and electrically-heated prototypes, which have been constructed and tested by Nuclear Materials & Equipment Corp. (NUMEC) of Apollo, Pa., have yielded im-



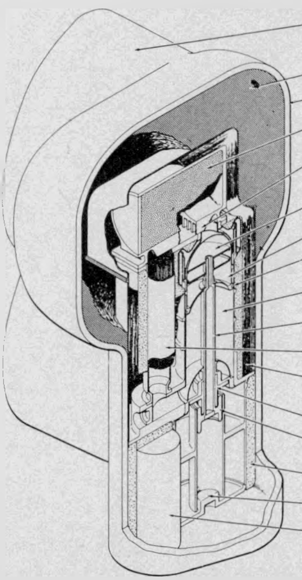
Cross-Section of the 10-Watt SNAP–21 undersea radioisotope energy system being developed for the AEC by the Minnesota Mining and Manufacturing (3M) Co., St. Paul, Minn. The SNAP–21 is designed for 5-year unattended operation, providing power for such uses as undersea telemetry and recording devices, navigational aids, and defense systems. The units are scheduled to be tested in the Pacific Ocean, off the coast of California, during 1969.

portant engineering data. Certain critical areas have been identified and are being resolved. Fabrication and testing of fueled prototype units will be completed by NUMEC in 1969.

Radioisotope Power System for Artificial Heart

Conceptual design studies of implantable radioisotope engines to supply mechanical power for pumps which would assist or replace functions of a diseased or damaged heart[8] have been completed by four firms which were selected in 1967 to make parallel design studies—Aerojet-General Corp., San Ramon, Calif.; Donald W. Douglas Laboratories, Richland, Wash.; Thermo Electron Corp.; Waltham, Mass.: and Westinghouse Electric Co., Pittsburgh, Pa. All of the concepts studied appear to be feasible; that is, they can be developed within the current state-of-the-art and still meet the known requirements for such a power source (see "Plutonium-238 Heat Source for Artificial Heart" item later in this chapter). While a number of difficult engineering

[8] See p. 181, "Annual Report to Congress for 1967."



A Modified Stirling Cycle Engine is being developed by the Aerojet-General Corp., San Ramon, Calif., for the AEC as a completely implantable power supply for a circulatory support system. The engine converts thermal power from a radioisotope heat source to mechanical power which can be used to pump blood. Since the system is to be totally implanted in the body and must rely on limited thermal power input, both thermodynamic efficiency and small size are critical. Reliability and engine life are also obviously critical. The Stirling cycle is attractive for this application because of its potentially high thermodynamic efficiency. However, it was necessary to make two major changes to the conventional Stirling engine to improve engine life and reliability before it could be considered for this application. The piston and crank mechanism of the conventional engine is replaced by a free piston arrangement to eliminate the requirement for high performance seals and bearings and to increase engine life. Power is extracted from the engine in the form of pressurized gas rather than as mechanical work; this permits the use of a simple intermediate fluid and bellows arrangement to couple the engine output to the circulatory support system.

problems have been identified, these are considered to be manageable and do not present insurmountable obstacles to the successful development of a totally implantable radioisotope engine for circulatory support systems.

In connection with this project, two plutonium-238 heat sources lent to a National Heart Institute contractor (Thermo Electron Corp.) have been implanted in dogs to evaluate the capability of animals to adjust to extra heat. A 16-thermal-watt source was implanted in the fall of 1967 and a 24-thermal-watt source in the spring of 1968; to date, neither dog has shown any ill effects from having this source of heat and radiation in the body.

Life Support System

Following the successful demonstration of the radioisotope powered water recovery system [9] by the General Electric Space Technology Center, Philadelphia, Pa., a design study was completed by Lockheed Missiles and Space Co., Sunnyvale, Calif., of an integrated multi-component life support system for aerospace application employing radioisotopes for thermal energy. The objective of this study was to evaluate radioisotope thermal energy and other heat sources to determine the optimum energy source for various life support functions. The resultant conceptual design uses individual plutonium-238 heat sources in an oxidizer for removal of trace contaminants from the spacecraft atmosphere and in a combined incinerator waste water-recovery unit. A third source heats a central heat transfer fluid loop to supply energy for temperature and humidity control. The unit for incineration of waste and recovery of water from waste water and vapor was chosen for detailed design, fabrication, and test.

ISOTOPES FUEL DEVELOPMENT

As radioisotopes decay, the heat (thermal energy) generated can be used directly for heating or it may be converted to mechanical or electrical energy by appropriate means. The characteristic type of radiation given off, half-life, heat potential, and chemical form stability are such that each radioisotopic fuel source must be "tailored" for its intended use. Exhaustive development and test efforts are used to establish the characteristics and behavior of the various isotopic fuel forms in their intended environments so that they can meet the stringent operational and safety requirements imposed on these devices when used in practical energy systems.

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[9] See p. 214 "Annual Report to Congress for 1966."

Polonium-210

Polonium-210 (half-life: 138 days) is being developed as a heat source for 90 to 150-day missions that demand a high "specific power" (thermal power per unit volume or weight) and a minimum of shielding. Rare earth-polonium fuel compounds that remain relatively stable under vacuum or inert atmospheric environments are being studied at Mound Laboratory and Pacific Northwest Laboratory (PNL). A part of this effort is a program to develop and provide a polonium-210 fuel form for the SNAP–29, radioisotope thermal generating system being developed by the nuclear systems divisions of Martin-Marietta Co. Because of the instability of available polonium fuel compounds, a concentrated effort is being made at Mound and PNL to develop a fuel form which will reduce the possibility of liberating the isotope under atmospheric conditions. This work includes development of a unique microencapsulation concept at PNL wherein individual microparticles (0.010 to 0.20 inches) are coated to give them complete inertness and stability in adverse launch pad, space, reentry and disposal environments.

Methods for increasing the capability for production, separation, and purification of the polonium metal—the starting material for any polonium fuel form under investigation—have been defined. Production processing equipment has been procured and is being installed, which is expected to reduce the cost. Process improvements are essential to further reduce the costs for providing the quantities of this isotope that would be required for heat sources. Increases in the reactor production rate of polonium-210, which is made by irradiating relatively large amounts of bismuth, have been made at Savannah River. Particularly significant is the development and demonstration of a potentially revolutionary high-temperature pyrochemical process for recovering polonium from irradiated bismuth. The polonium is extracted with molten sodium hydroxide and the bismuth stays in the metallic state for direct recycle to the reactor. The new process, developed by Pacific Northwest Laboratory and Atlantic Richfield Hanford Co. scientists, promises to drastically reduce the cost of large-scale polonium production.

Curium-244

During 1968, efforts were continued at Oak Ridge National Laboratory and Savannah River Laboratory to characterize curium-244 as to chemical, physical, radiation, and other properties. Capsule design and closure sealing methods and designs are under investigation. Curium-244 (half-life: about 18 years), has the attractive combination

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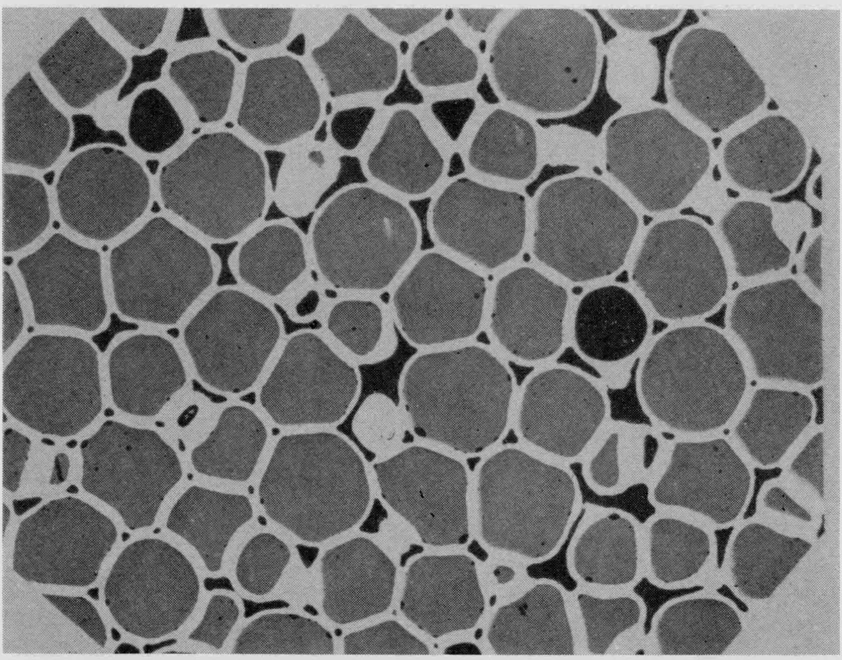
of a reasonably high specific thermal activity, a relatively long operational life, and the availability of a thermally and chemically stable compound. However, the neutron radiation of curium-244 does require more shield weight than other alpha particle emitting fuels under development, plutonium-238 and polonium-210.

Plutonium-238

During 1968, there was continued development of plutonium-238 in the form of plutonium dioxide microspheres (half-life: 87.5 years) for use in radioisotope power units. In addition to the long half-life, desirable properties of this material are relative chemical and biological inertness, high melting point, thermal, chemical, and radiation stability, and ease of handling. Development of the production process for plutonium dioxide microspheres is underway at the Mound and Oak Ridge Laboratories. Oak Ridge National Laboratory has demon-



Photomicrograph of a Sample of the new plutonium dioxide composite fuel form being developed at the AEC's Mound and Oak Ridge laboratories. The dioxide microspheres are completely enclosed in the high temperature metal matrix, providing containment and improved heat removal capability for plutonium-238 fueled heat sources.

strated a pilot plant for this new microsphere production process. The pilot plant unit fabricated at ORNL was subsequently installed at the Mound Laboratory facility and is expected to be operational in 1969. Mound Laboratory has developed a method for reducing the neutron radiation which will be tested on a pilot-plant scale in late 1968. Using the microsphere oxide fuel form, several test capsules were fabricated for evaluation in the fuel technology program.

During 1968, the DART II (Decomposed Ammonia Radioisotope Thruster), a propulsion device for attitude control positioning of a spacecraft, was fueled and demonstrated successfully in a simulated space environment. The DART thruster was designed and fabricated by TRW Systems, Redondo Beach, Calif., under a U.S. Air Force contract, and demonstrated at the Mound Laboratory.

Plutonium-238 Heat Source for Artificial Heart

If plutonium-238 is used as a heat source in a circulatory support system (see previous "Artificial Heart" item in this chapter), it must contain essentially no elemental impurities of low atomic weight because the alpha particles given off by the plutonium-238 interact with such trace impurities to increase the neutron emissions above the irreducible minimum from the spontaneous fission of plutonium-238. A procedure for electrorefining liquid plutonium-238 metal was developed at Los Alamos Scientific Laboratory. Evaluation of the electrorefined product revealed a very low elemental impurity level, which was confirmed by a neutron emission rate very close to that caused by spontaneous fissions. This material has the lowest external radiation level and highest elemental purity of any plutonium-238 metal ever produced from production grade feed.

Plutonium-238 has been produced in research and development programs at Hanford by way of irradiation of neptunium-237. It has been determined that the characteristics of Hanford reactors are such that the Pu^{236} content of Pu^{238} produced is about 0.5 to 0.6 p.p.m., depending upon the irradiation times, when conventional neptunium-aluminum targets were used. Pu^{238} with Pu^{236} content as low as 0.3 p.p.m. was produced when neptunium-graphite targets were irradiated, and some future reduction in Pu^{236} content are predicted when irradiations in a tailored neutron spectrum are made. Production of Pu^{238} with these Pu^{236} contents is a significant achievement in consideration of Pu^{238} for medical programs since the daughters of Pu^{236} result in very penetrating gamma radiation.

Promethium-147

At Pacific Northwest Laboratory (PNL), the long-term compatability tests at 2,012° F. of capsules loaded with samarium oxide as a nonradioactive stand-in[10] for promethium-147 (half-life: 2.6 years) have continued successfully. Encapsulation of the radioactive promethium-147 sesquioxide (Pm_2O_3) has become a more routine operation as evidenced by the fabrication of 19 capsules, from nine different metals, for additional compatability tests at more than 2,000° F. These Pm capsules have been undergoing heat testing for several months, leading to destructive examination in May 1969 to determine the compatability of promethium with the various cladding materials.

In other promethium work at Pacific Northwest Laboratory, the first successful preparation of metal was accomplished.

A new ion exchange technique, using nitrilotriacetic acid as the elutant was developed at PNL for the purification of promethium-147. This technique provides excellent separation while reducing processing time by half.

Cobalt-60

Tests directed at finding suitable materials for encapsulation of cobalt-60 for possible use as isotopic heat sources continued during 1968 at the Savannah River Laboratory.

Heating tests in air at typical heat source conditions, 1,562° to 1,832° F., were continued on various oxidation-resistant cobalt and nickel base alloys encapsulating either radioactive cobalt-60 or stable cobalt-59. At 1,562° F., several capsules of one such alloy ("Inconel 600") containing cobalt-60 were successfully heated for up to 5,000 hours and a similar capsule containing cobalt-59 for up to 10,000 hours. No changes in dimensions or loss of integrity were detected in any of these capsules and the oxidation and reaction layers were negligible.

Thulium-170

A fuels technology development program to determine the properties of thulium-170 as related to thermal applications is in progress at Sanders Nuclear Corp., Nashua, N.H., and Oak Ridge National Laboratory. These properties under investigation include thermal stability, materials compatability (through 2,912° F.), radiation characteristics as a function of shielding, thermal conductivity, and seawater-leach rates. The thulium-170 for radiation shielding studies was produced in AEC production reactors.

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[10] See p. 184, "Annual Report to Congress for 1967."

Curium-244 and Americium

The largest single quantity of curium-244 ever to be produced has been separated and purified at Richland, Wash., by Atlantic Richfield Hanford Co., in part using technology developed by Pacific Northwest Laboratory. This is the first recovery of that radioisotope from waste streams from the reprocessing of spent power reactor fuel—a source that will eventually mushroom as nuclear power reactors proliferate. Like some other radioisotopes, curium-244 is an excellent heat source for remote applications. In addition to the curium-244, a much greater quantity of plutonium-americium was recovered.

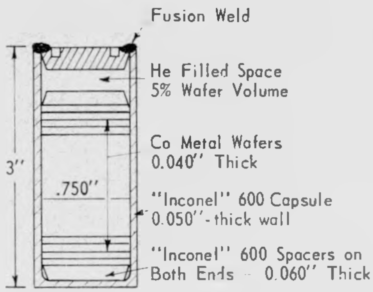
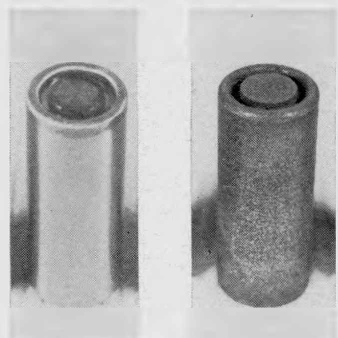


DIAGRAM OF CAPSULE



Before Heating After Heating

TYPICAL CAPSULES

CROSS SECTION THROUGH WALL OF HEATED CAPSULE

A Capsule Fabricated From "Inconel" 600 and filled with 15,000 curies of irradiated cobalt (Co) metal was heated in still air at 1,562° F. for 5,000 hours. The capsule maintained its integrity and microscopic examinations of representative cross sections revealed no deleterious effects of the heating on either the capsule wall or the cobalt in the capsule. Comparison with similar results on companion capsules filled with unirradiated cobalt indicates little effect of the radiation field. "Inconel" 600 is one of several materials being evaluated at the Savannah River Laboratory at prospective materials for encapsulating irradiated cobalt for use in heat sources.

Chapter 10

ISOTOPIC RADIATION APPLICATIONS

ENVIRONMENT & OCEAN SCIENCES

Increased emphasis has been placed on development of radioisotope and radiation techniques to aid in environmental pollution detection and control and to assist in the exploration and economic development of the oceans' resources. (Uses of isotopic heat are discussed in Chapter 9—"Specialized Nuclear Power Units.")

Atmospheric Sulfur Pollution Analysis

Brookhaven National Laboratory has made considerable progress in its use of stable isotopes of sulfur to study the source, quantities, meteorological distribution, and ultimate fate of sulfur dioxide, an air pollutant of national concern, emitted to the atmosphere from the stacks of fossil-fuel-burning plants.[1] The technique involves measuring the isotopic ratio of sulfur-32 to sulfur-34 in samples of sulfur dioxide from the air. Major achievements during 1968 were the: (*a*) Development of a special airborne filter pack for sampling sulfur dioxide; (*b*) measurement of background isotope ratios at three power-plant sites and in the air above these locations; (*c*) selection of a fuel oil with a sulfur ratio sufficiently different from that in the environment to permit its use as a tracer; and (*d*) design and procurement of an environmental test chamber to study the effect of atmospheric conditions on the measurements.

Stack Gas Check on Combustion

Three contracts—with International Chemical and Nuclear Corp., Pittsburgh, Pa.; Texas Nuclear Corp., Austin, Tex.; and Industrial

[1] See p. 193, 'Annual Report to Congress for 1967."

Nucleonics Corp., Columbus, Ohio—to study the feasibility of using nuclear methods to determine sulfur dioxide content in stack gases were completed. Laboratory work was initiated by Industrial Nucleonics on a method identified as having considerable potential. The purpose of these studies is the eventual development of a device for continuous control of combustion through the sulfur dioxide discharge from fossil-fueled powerplants. This method involves a continuous withdrawal of a metered amount of gas from an operating stack, bubbling the gas through a suspension of mercurous chloride to form soluble bisulfitomercurate ions, and measurement of these ions by X-ray absorption in an adjoining measurement cell.

Littoral (Sand) Drift

Continuing progress was made during 1968 in a project [2] for tracing littoral drift (shifting of coastal sand) north of Santa Barbara, Calif., with radioisotopes. Such information can be particularly useful in harbor siting and in selecting the best place for breakwaters to halt beach erosion.

In this project, sponsored by five Federal agencies and the State of California,[3] sand from the beach under study is labeled with xenon-133 by treatment with the gas at high temperature. This labeling technique is similar to that developed by Panametrics, Inc., Waltham, Mass., for tagging a wide variety of solids with krypton-85. The tagged sand is then deposited in the surf at high tide and its movement is followed by four scintillation detectors housed in a 300 pound nickel ball that is towed behind an amphibious vehicle. This unique underwater mobile detector system and the ancillary computer and data treatment programs were developed and are operated during field tests by Oak Ridge National Laboratory.

In recent tests at Surf, Calif., the sand was placed on a line extending down the beach into and through the surf. Two injections were made, each using 150 gallons of xenonated sand. The first injection made during relatively calm conditions, was monitored for 4 days and showed little movement except along the beach face. The second injection was made under much higher wave conditions, and showed rapid dispersal of the sand. In the second experiment, the sand was soon lost through combined burial and inability to detect the comparatively soft radiation from the xenon-133.

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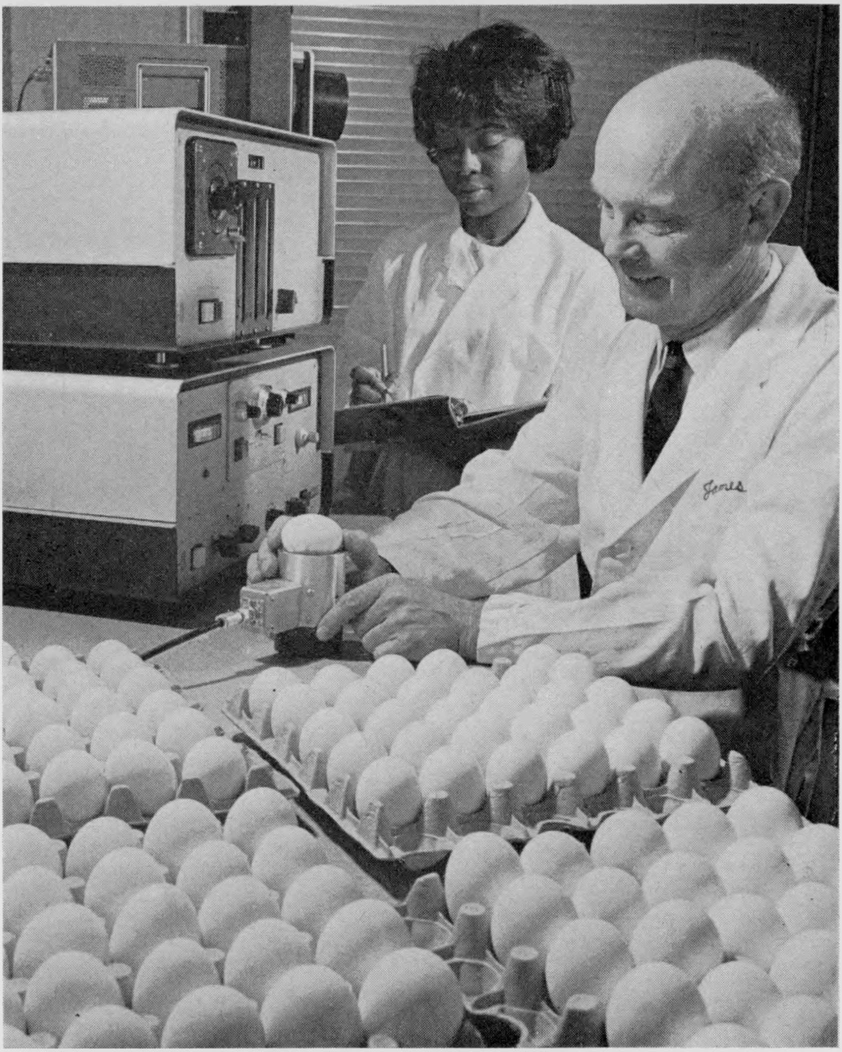
[2] See pp. 194–195, "Annual Report to Congress for 1967."

[3] The AEC, NASA, Department of the Army, Department of the Navy, Department of the Air Force, and the State of California's Department of Water Resources.



An Isotopic Gauge to Test Eggshell Strength has been developed under a joint effort with Oak Ridge National Laboratory and Department of Agriculture. Beta particles from ruthenium-106 bombard a small area of the eggshell and a Geiger counter determines the number of particles reflected—the more betas returned, the denser the shell. The device makes it possible to nondestructively study the impact resistance of eggshells as influenced by such factors as diet and heredity. The instrument is currently being evaluated by the Department of Agriculture and the Department of Interior, Wildlife Service. If adopted, this instrument will be used to help reduce the national egg loss by breakage—which was $25 million in 1966. At least three industrial firms have expressed an interest in manufacturing this instrument.

The experiment was repeated with gold-198 labeled sand. The results were somewhat similar, except that the sand could be followed much further because of the higher energy radiation from gold-198.

ISOTOPIC RADIATION SYSTEMS

While many different applications using isotopic radiation to measure the properties of materials have been developed in the past quarter-century, there remains a significant potential for further development.

On-Line Analysis for Process Control

A project[4] to develop on-line analytical measurements, both by neutron activation and by X-ray fluorescence, for process control of industrial raw materials has been concluded by Texas Nuclear Corp., Austin, Tex. For example, a pilot plant for on-line analysis of copper ores, using a neutron generator and a gamma ray spectrometer was constructed. Excellent results for copper were obtained, but results for aluminum, silicon, and iron were less favorable. Similarly, a raw-mix cement plant, neutron activation analysis was found to be suitable for the determination of aluminum and silicon, whereas X-ray fluorescence was best suited for calcium and iron.

Helicopter Formation-Keeping System

A helicopter station-keeping system[5] developed by Industrial Nucleonics Corp., Columbus, Ohio, was successfully flight tested, using three helicopters, at the Patuxent River Naval Air Test Center (Md.) in June. The technique, which makes possible close formation flying under limited visibility conditions uses a radioisotope source and detector, and provides a visual display from which the helicopter pilot can immediately determine the range and bearing of each similarly equipped helicopter. The equipment provides bearing accuracies within 5°, and range measurement accuracies within 10 percent out to the specified operating range of 500 feet.

Hydrogen Detector

An instrument has been developed by Panametrics, Inc., Waltham, Mass., for the detection of hydrogen in the interstage area of the Saturn space vehicle. This is important because hydrogen leaks can be a serious explosion hazard and a major advantage of the instrument is its

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[4] See pp. 232–234, "Annual Report to Congress for 1966."
[5] See p. 220, "Annual Report to Congress for 1965."

A Lightweight Portable X-Ray Fluorescence Spectrometer analyzer has been developed which uses radiation from a selected isotope to excite the characteristic X-rays of an element being determined. The intensity of the emitted X-rays is a measure of the amount of material present. The instrument can be operated in the laboratory, in the field for geological exploration, or in the factory for industrial analysis and control of raw materials and manufactured products. The spectrometer is suitable for determination of sulfur and ash content of coal, copper, and iron content of copper ores, gold and silver in ore concentrates, and calcium and iron content in raw cement mix. Ten prototype instruments were placed in use with several industrial concerns for operational evaluations under field or plant conditions. Various models of the new spectrometer are being manufactured commercially by the organizations that did the development work for the AEC—Texas Nuclear Corp., Austin, Tex., and Panametrics, Inc., Waltham, Mass.

explosion-proof design. The instrument can detect up to 3 percent hydrogen in air or up to 10 percent hydrogen in nitrogen. The measurement is made by counting the krypton-85 released from kryptonated platinum dioxide[6] as the platinum dioxide reacts with the hydrogen.

[6] Platinum dioxide into which krypton-85 has been forced at high temperature and pressure.

Isotopic Thermal Conditioners are being used in aircraft units to save warmup time. An isotopic heat source fueled with 60 watts (168,000 curies) of promethium-147 is shown being inserted into a thermal preconditioning unit designed to heat an aircraft inertial measuring unit. This thermal preconditioning eliminates the warmup time of the instrument. The unit has been flight tested by the Air Force to simulate flight conditions for the Advanced Manned Strategic Aircraft. The component parts of the heat source are shown in the inset.

Radiation Processing

Radiation processing is the use of ionizing radiation as a source of energy to produce chemical, physical, or biological changes for practical applications. The AEC has completed a detailed study of its program in this field and its relationship to work being done by industry. As a result, more emphasis is being placed on the following: (*a*) increased amount of basic radiation chemistry research, particularly with universities; (*b*) increased ratio of non-Government/Government support; (*c*) increased efforts toward educating industry on the potential of radiation processing applications; and (*d*) the transfer to industry of the developed technology.

In several instances the goal of transferring AEC-supported development technology to industry has already been partially or fully realized.

Wood-Plastic Combinations

With the entry of a third industrial organization [7]—Atlantic Richfield Co., Philadelphia, Pa.—into the wood-plastic commercial field, further support of research and development projects in this area has been halted until the impact of this entry has been assessed. In addition, Radiation Machinery Corp., Parsippany, N.J., has announced that construction is underway on a plant for the production of radiation-processed wood-plastic materials. Basic research and development by West Virginia University (Morgantown), and testing and evaluation by Research Triangle Institute, Durham, N.C.—the two existing AEC-sponsored projects—are being terminated.

Polyethylene

As a result of basic work done at Brookhaven National Laboratory on the radiation polymerization of polyethylene, several companies have become interested in this project, to the point of building pilot plants; therefore, the AEC has discontinued development efforts.

Emulsion Polymerization

In a cooperative program with industry, a pilot plant demonstration of the radiation-induced polymerization process for producing vinyl acetate latex, was completed. This chemical is in wide use as a paint

[7] Lockheed-Georgia Co., Marietta, Ga., and the American Novawood Corp., Lynchburg, Va., have been active in this field for some time.

base. The plant, built at private expense by Neutron Products, Inc., Dickerson, Md., showed, under AEC contract, the practicality of scaling up the emulsion polymerization process from laboratory to semicommercial production. Concurrently, also under AEC contract, the University of North Carolina, at Raleigh, is studying a new radiation-polymerized emulsion system which may provide polymers not previously made by standard techniques.

Concrete-Polymer Materials

The development of concrete-polymer composites as an improved material of construction is the objective of a joint program with the U.S. Bureau of Reclamation and the Office of Saline Water. Research on impregnation and polymerization methods and techniques is being performed at Brookhaven National Laboratory with sample testing by the Bureau of Reclamation. Preliminary screening experiments have indicated marked improvements in properties of radiation produced concrete-polymers as compared to control specimens of untreated concrete.

Food Preservation

The Food and Drug Administration (FDA) decided not to grant the Army's request for approval of radiation sterilized canned smoked ham for public consumption. It is understood that the FDA action on the petition does not indicate an inherent lack of wholesomeness and safety of irradiated food, but that the data presented to FDA did not prove conclusively that radiation sterilized ham was safe.

The AEC is withdrawing its request for FDA approval of radiation-pasteurized East Coast fish fillets pending the accumulation of additional wholesomeness and public health safety data. The additional experiments will include test results from feeding animals with fish products prepared at radiation doses of interest to the food pasteurization program. The AEC maintains constant liaison with FDA regarding the updating of procedures before initiation of any new feeding studies. More realistic target dates, allowing additional time for completion of data gathering and for petition action, will be set.

Meat Irradiator Project

Following initiation of a contract in July 1967 with IRRADCO [8] to design, construct, and operate a pilot plant meat irradiator at Allentown, Pa., a detailed design was undertaken and completed. As a

[8] See p. 192, "Annual Report to Congress for 1967."

result of the adverse action on the Army's ham petition by the FDA construction plans have been suspended.

Cost-Benefit Study of Meat Pasteurization

A study on radiation processing of meats for shelf-life extension by Daniel Yankelovich, Inc. (New York City), investigated the alternatives of freezing, controlled atmosphere, improved sanitation, and radiation as a means of achieving the benefits of centralized meat cutting. The study concluded that: (*a*) if centralized cutting were to be established by retail chains in the environs of the stores to be served, sanitation control under modern plant conditions would provide the requisite 1-week shelf life (from time of cutting to consumer); and (*b*) that if centralized cutting were to be established by packers at slaughterhouse locations, the processing alternatives of freezing, irradiation, and perhaps controlled atmosphere would be required to provide the requisite 3-week shelf life. While each of these alternatives would provide roughly the same economic benefit the advantage would be with freezing or controlled atmosphere. These technologies are more advanced at the present time than irradiation. Also, they do not require prior approval by FDA. Industry is actively investigating model centralized cutting operations based on the technologies of freezing and controlled atmosphere. These are expected to lead to pilotplant operations within the next year.

Chapter 11

PEACEFUL NUCLEAR EXPLOSIVES

THE PLOWSHARE PROGRAM

During 1968, progress was made toward demonstrating the feasibility of using nuclear explosions for peaceful uses, specifically for large-scale earthmoving and the stimulation of low-producing natural gasfields. Three nuclear cratering experiments were conducted with a high degree of success and the first joint Government-industry Plowshare experiment for stimulating natural gasfield production yielded valuable preliminary gas flow data. Advances were also made in reducing the amount of radioactivity produced by nuclear excavation explosives.

Plowshare Explosion Services

The Non-Proliferation Treaty which was signed by the United States, United Kingdom, the Soviet Union, and 50 other countries, on July 1, 1968, and currently awaits Senate ratification, specifies in Article V that ". . . Each party to the treaty undertake . . . 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 . . ." In addition, legislation was introduced in the Congress to authorize the AEC to engage in projects with industry for other than research purposes, a step toward the goal of providing a useful and economic explosion service to users of the Plowshare technology.

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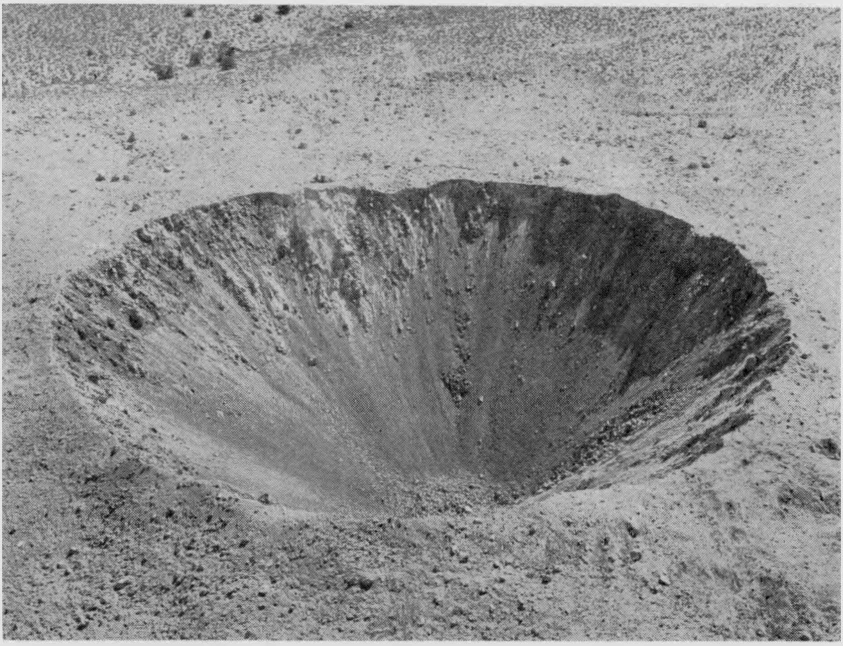
NUCLEAR EXCAVATIONS

Three nuclear cratering experiments—Cabriolet, Buggy, and Schooner—were conducted to gain further information on how craters are formed in hard rock. Of particular interest was whether computer predictions of crater size in hard rock, based on past experience in desert alluvium (sandy gravel), would be proved out. Data on the amounts of radioactivity released to the atmosphere from these explosions were compared with preshot predictions to verify and refine existing predictive capability.

Project Cabriolet

On January 26, 1968, a 2.5-kiloton (kt.) explosive was detonated in hard, dry, rhyolite rock at the Nevada Test Site (NTS). This project was an important step in determining the basic cratering effects of a



Project Cabriolet Was a Cratering Experiment in hard, dry, rhyolite rock at the Nevada Test Site on January 26, 1968, to obtain basic data on crater formation and the distribution of radioactivity from a low-yield nuclear explosive. The predicted yield was 2.6 kilotons; the measured yield, 2.3 plus or minus 0.5 kilotons. The explosive, buried at 170 feet, produced a typical crater, with dimensions of: radius, 180 feet; depth, 120 feet; lip crest radius, 214 feet; and volume, 180,000 yards. Experimental results for ground shock and surface motion were consistent with preshot predictions.

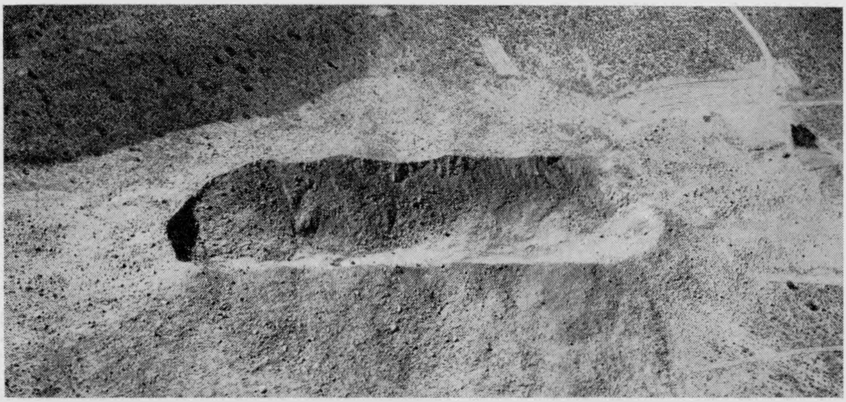
nuclear explosion occurring at the depth underground at which, according to computations, the best crater would form. Although Cabriolet was 40 times smaller in size than the July 6, 1962, Sedan (100 kt.) cratering experiment[1] in desert alluvium, it was an important step forward since it was six times larger than the last similar experiment (Danny Boy, a 0.4 kt. experiment conducted March 5, 1962, at the NTS in hard rock). Hard rock is expected to be the most frequently encountered material in future excavation projects.

Cabriolet was highly successful, releasing only a small amount of radioactivity while producing a crater about 360 feet in diameter and 120 feet deep as had been predicted.

Project Buggy

The Buggy experiment, on March 12, at NTS, was the first nuclear row-charge experiment to be conducted by the United States. The experiment consisted of the simultaneous detonation in hard rock of a row of five nuclear explosives each having a yield of about 1 kiloton (equivalent to 1,000 tons of TNT). The explosion created a ditch about 255 feet wide, 855 feet long, and 65 feet deep, which compared very closely with the predicted preshot dimensions. Only a small amount of radioactivity was released to the atmosphere and most of that was deposited within the area immediately downwind from the detonation.

[1] See pp. 241–250, "Annual Report to Congress for 1962."



The First Nuclear Row-Charge Experiment to be conducted in the U.S., Buggy created a crater approximately 855 feet long, 255 feet wide, and 65 feet deep. It was produced by the simultaneous detonation of five nuclear explosives of approximately 1 kiloton each on March 12, 1968. The explosives were buried 135 feet deep and spaced 150 feet apart in hard rock at the Nevada Test Site. The arrow (at *right*) points to a pickup truck which provides a comparison of the size of the crater.

The success of the Buggy experiment is particularly significant because of the critical relationship between a simple, effective ditching technique and the feasibility of using nuclear explosions for excavation projects such as the construction of canals and harbors, clearing waterways, or removal of overburden in near-surface mining operations.

Project Schooner

Project Schooner, a 35 kt. nuclear experiment, was conducted on December 8 at the NTS. The experiment produced a crater 270 feet deep and 800 feet in diameter. It further extended the hard rock nuclear cratering data collected from Cabriolet to that of a nuclear experiment of a higher yield, approaching what would be a useful size for practical excavation projects.

Nuclear Explosive Development Experiment

On September 17, the Stoddard event, a low intermediate yield, fully contained underground nuclear explosion was successfully conducted at the NTS. Stoddard was another step in a series of experiments to develop special nuclear explosives that will minimize the amount of radioactivity produced in excavation projects.

Interoceanic Sea-Level Canal Studies

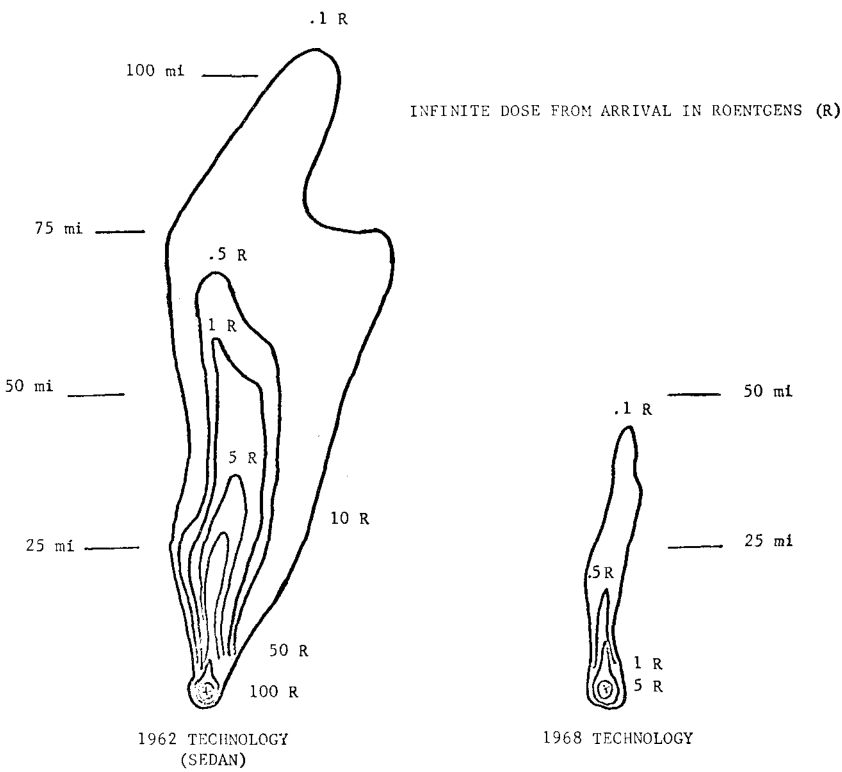
Since the discovery of the Isthmus of Panama by Vasco Nunez de Balboa in 1513, men have dreamed of a sea-level, man-made strait adjoining the Atlantic and Pacific Oceans. Nuclear cratering experiments conducted by the AEC indicate that nuclear excavation of a sea-level canal is a possible means of constructing such a waterway.

In relation to its program of nuclear cratering experiments, the AEC, in support of the Atlantic-Pacific Interoceanic Canal Study Commission, continued to develop data on the technology, costs, and safety of using nuclear excavation for sea-level canal construction. During 1968, AEC contractors completed the data collection phase [2] of their onsite ecological and environmental studies in Panama and Colombia. The findings of these studies will be used by the Canal Study Commission in its final report in December 1970, and recommendations to the President regarding how, where, and when a sea-level canal should be constructed across the American Isthmus.

[2] See pp. 252–255, "Annual Report to Congress for 1962."

UNDERGROUND ENGINEERING

The Plowshare program is also directed toward the development of a technology known as nuclear underground engineering. Proposals for joint Government-industry or State-sponsored projects or studies have been made to apply this new technology to stimulate gas production; the recovery of oil from oil shale; the solution mining of low-grade copper ores; the creation of storage capacity for natural gas under pressure; and the capture of runoff precipitation from arid areas. Nuclear underground engineering concepts are based on the fracturing of rock by the nuclear detonation; and on the size, shape, and volume of material over which the explosion effects are distributed.



The Fallout Patterns Are Illustrative of the advances made in reducing the amount of radioactivity released to the atmosphere from nuclear cratering explosions as a result of improved explosive designs and the use of special emplacement techniques. The pattern on the *left* is similar to that of Project Sedan, a 100-kiloton nuclear cratering experiment in alluvium conducted in July 1962, at the Nevada Test Site. The pattern on the *right* shows what the Sedan pattern would look like using 1968 technology.

Natural Gas Stimulation

Based on industry surveys, the *Oil and Gas Journal* predicts that if the discovery rate of natural gas does not increase, the U.S. gas reserves will not be able to meet the foreseen demands by 1975. An effective and economical means of helping to solve this serious problem may be offered through the use of nuclear explosions to bring certain marginal natural gas fields into production.

Project Gasbuggy

Initial gas production tests conducted at the Project Gasbuggy site during June and July of 1968 were encouraging. Additional production tests were begun in November and will continue into 1969 to evaluate production characteristics of the gas reservoir. Gasbuggy, the first nuclear-gas stimulation experiment, was conducted on December 10, 1967, near Farmington, N. Mex.[3] The explosion created a chimney approximately 330 feet high with a volume of at least 2 million cubic feet, 3,900 feet beneath the earth's surface.

Analysis to date of gas samples to determine both chemical and radioactive composition of the gas indicates that radioactivity concentrations, particularly that of tritium were less than predicted. As expected, analysis of gas samples to date have revealed the presence of tritium in the gas, although at lower levels than predicted. The tritium was produced as a result of deliberately using a thermonuclear type explosive for the experiment in order to study: (*a*) the degree of contamination produced by such an explosive; (*b*) the chemical form taken by the tritium; and (*c*) the best means of dealing with the tritium. Should further analysis reveal tritium to be a major consideration, special explosives may be designed for gas stimulation projects to minimize the production of tritium.

Other Gas Stimulation Proposals

Several other gas stimulation experiments have been proposed or brought to the attention of the AEC.[4]

Rulison. The Rulison experiment, proposed by the Austral Oil Co. in conjunction with CER Geonuclear Corp., would involve a 40-kiloton detonation at a depth of 8,500 feet, 15 miles southwest of Rifle, Colo., in a thick gas-bearing formation. Contract negotiations are tentatively

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[3] See pp. 199–200, "Annual Report to Congress for 1967."
[4] See pp. 200–202, "Annual Report to Congress for 1967."

planned for early 1969 and the detonation is planned for late spring of 1969.

Dragon Trail. An experiment, called Dragon Trail, was proposed jointly by the Continental Oil Co. and CER Geonuclear Corp. It calls for the detonation of a 20 kiloton nuclear exposive 2,950 feet underground at a site about 50 miles north of Grand Junction, Colo. At present, technical and operational safety planning is being carried out in preparation for a possible detonation in the summer of 1969.

Possible Wyoming Projects. Two suggestions for gas stimulation experiments in the Pinedale area of Wyoming have been received. One was proposed by the El Paso Natural Gas Co., the AEC's industrial partner in the Gasbuggy experiment, and the other, called WASP (Wyoming Atomic Stimulation Project), by a group of six independent oil companies with the International Nuclear Corp., acting as operator.

Other Underground Engineering Proposals

Work continued in 1968 to design experiments to investigate the use of nuclear explosions to recover oil from oil shale, to prepare low-grade copper deposits for subsequent solution mining, and to create storage areas for gas and water.

A Companion Oilshale Program to the Bronco experiment is the work being done by the U.S. Bureau of Mines both to develop retorting techniques to recover the oil from the oil shale and to evaluate shale beds for potential nuclear exploitation. Shown *above* are two blocks of shale that will be used in the 150-ton retort experiment being conducted at the Bureau's Petroleum Research Center, at Laramie, Wyo.

Oil Shale Development

The Bronco experiment, proposed in 1967 [5] to the AEC and the Department of the Interior by CER Geonuclear Corp., on behalf of about 15 oil and related companies, involves the development of a technique to recover oil from oil-bearing shales located throughout the States of Wyoming, Utah, and Colorado. The project site is located 23 miles east of Rangely, Colo. Government-industry contract negotiations were held during 1968 and the parties are currently reviewing possible contract arrangements.

Copper Extraction

Under the most advanced conventional mining and treatment methods, some low-grade copper deposits cannot be recovered economically. Kennecott Copper Corp., in 1967 proposed the Sloop experiment to the AEC and the Department of the Interior to determine the feasibility of solution mining (leaching) of a copper orebody fractured by a nuclear explosion. The details of the proposal are being defined and the experiment is planned to be carried out in 1970 at a site 9 miles northeast of Safford, Graham County, Ariz.

Natural Gas Storage

The Columbia Gas System Service Corp. has been studying the use of a nuclear explosion to create a chimney and associated fractured zone in thick impermeable rock formation for use as an underground storage area for natural gas under high pressure. This experiment, named Ketch, was proposed for a site in a State forest near Renovo, Pa. However, in July of 1968, Columbia withdrew its request to the Commonwealth of Pennsylvania to use the State forest land and is now looking for a new site in the State or elsewhere in the Appalachian area.

Arizona Water Study

A 12- to 15-month water study, given the name Aquarius, was begun in July. This study is being carried out by the AEC and the Department of the Interior in response to a proposal by the Governor of Arizona for cooperative studies of the feasibility of applying nuclear explosions to water resource management in his State.

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[5] See p. 205, "Annual Report to Congress for 1967."

Chapter 12

INTERNATIONAL AFFAIRS AND COOPERATION

INTERNATIONAL COOPERATION

As a world leader in nuclear energy, the United States, through the AEC, continued to advance the use of atomic energy for peaceful purposes by other nations by offering cooperation in the fields of information, material supply, training, personnel, and financial assistance to international organizations and foreign countries.

Significant developments during the year included the signature by over 80 nations of the Non-Proliferation Treaty, which when it enters into force will provide increased assurance against the spread of nuclear weapons to additional nations; the negotiation of several additional Agreements for Cooperation which brings to over 525,000 kg. the amount of U.S. enriched uranium which may be supplied abroad for peaceful purposes; and the continued strong support for the International Atomic Energy Agency and close cooperation with the European Atomic Energy Community (Euratom) in their programs for the peaceful uses of nuclear energy.

International Atomic Energy Agency

The U.S. support of the IAEA included cooperation in all of the agency's programs and through contributions to both its assessed budget and its voluntary budget employed for technical assistance to developing nations.

The 98-member IAEA held its 12th General Conference in September and continued its important work in all areas of the peaceful uses of nuclear energy. The IAEA safeguards system was extended in 1968 to cover fuel conversion and fabrication plants. Also in 1968, the Treaty for the Non-Proliferation of Nuclear Weapons, containing a safeguards article with important responsibilities for the IAEA, was opened for signature. Under the provisions of Article III of the treaty, the IAEA will be called upon to provide assurance that nuclear energy programs, in nonnuclear-weapon states adhering to the treaty, are not diverted to the manufacture of nuclear weapons or other nuclear explosive devices. The United States is assisting the IAEA with respect to safeguards by providing the services of U.S. technical experts, sharing the results of its research and development, and by providing safeguards training opportunities for agency staff members.

In accordance with the U.S. policy of transferring to the IAEA the safeguards responsibilities provided for in various bilateral agreements for cooperation [1] in the civil uses of atomic energy between the

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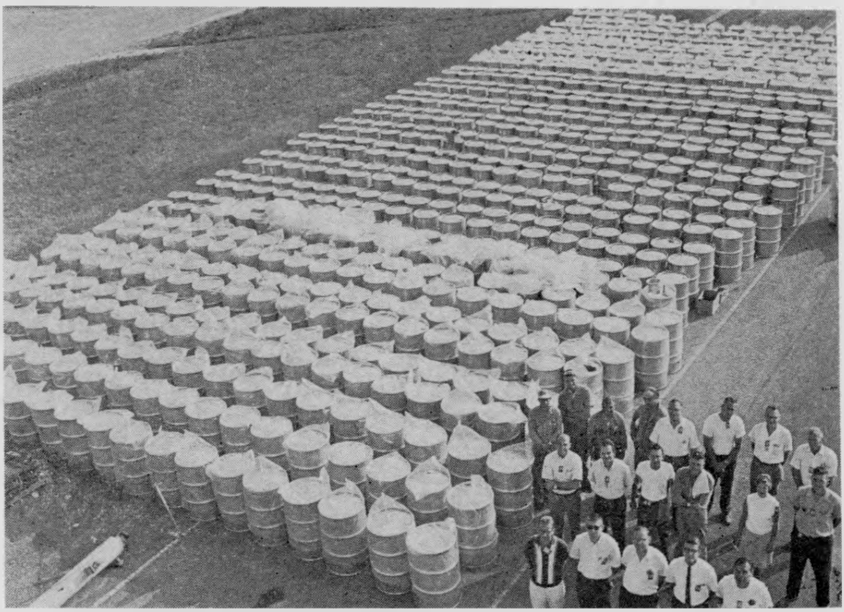
[1] Within the framework of the "Atoms for Peace" program, the United States has a number of bilateral Agreements for Cooperation under which it provides nuclear technology and materials to other countries. The agreements typically include "safeguards" clauses prohibiting the use of the U.S.-supplied equipment and materials for military purposes and also requiring strict inventory accounting and controls of the fissionable materials provided or generated during their use. As the foreign nation signatory to such an Agreement for Cooperation accepts placing these "safeguards" responsibilities under IAEA administration, a specific agreement to do so is concluded on a trilateral basis.



The Biggest Shipment of Heavy Water ever made from the AEC's Savannah River Plant occurred during 1968. Photo is a view of most of the 728 drums that made up the largest single sale of heavy water. The drums, each valued at $12,250, are arrayed in the photograph as they were individually sampled prior to shipment to the Swedish Atomenergi Company for use in the Marviken power reactor 100 miles south of Stockholm. Personnel shown include representatives of Atomenergi, the Gollob Analytical Laboratories, and the AEC; others are production and laboratory workers at the Savannah River Plant.

United States and other countries, four new trilateral safeguards agreements were signed bringing the total number of such agreements to 20. Trilateral agreements with four other countries are in various stages of negotiation. (See also Chapter 2—Safeguards and Material Management on other aspects of the safeguards activities.)

European Atomic Energy Community

The policy of close cooperation with the European Atomic Energy Community (Euratom) was in its 10th year; it began with the signing of the United States-Euratom Agreement for Cooperation in 1958. The United States continues to collaborate with Euratom principally in two research areas: (*a*) the joint research and development program aimed at improving the performance of light water reactors; and (*b*) fast reactor technology. An amendment to the Euratom Cooperation Act, passed by Congress in 1967, authorized the transfer to Euratom of up to 1,500 kg. of plutonium (an increase of 1,000 kg.) and up to 215,000 kg. of contained uranium-235 (an increase of 145,000 kg.).

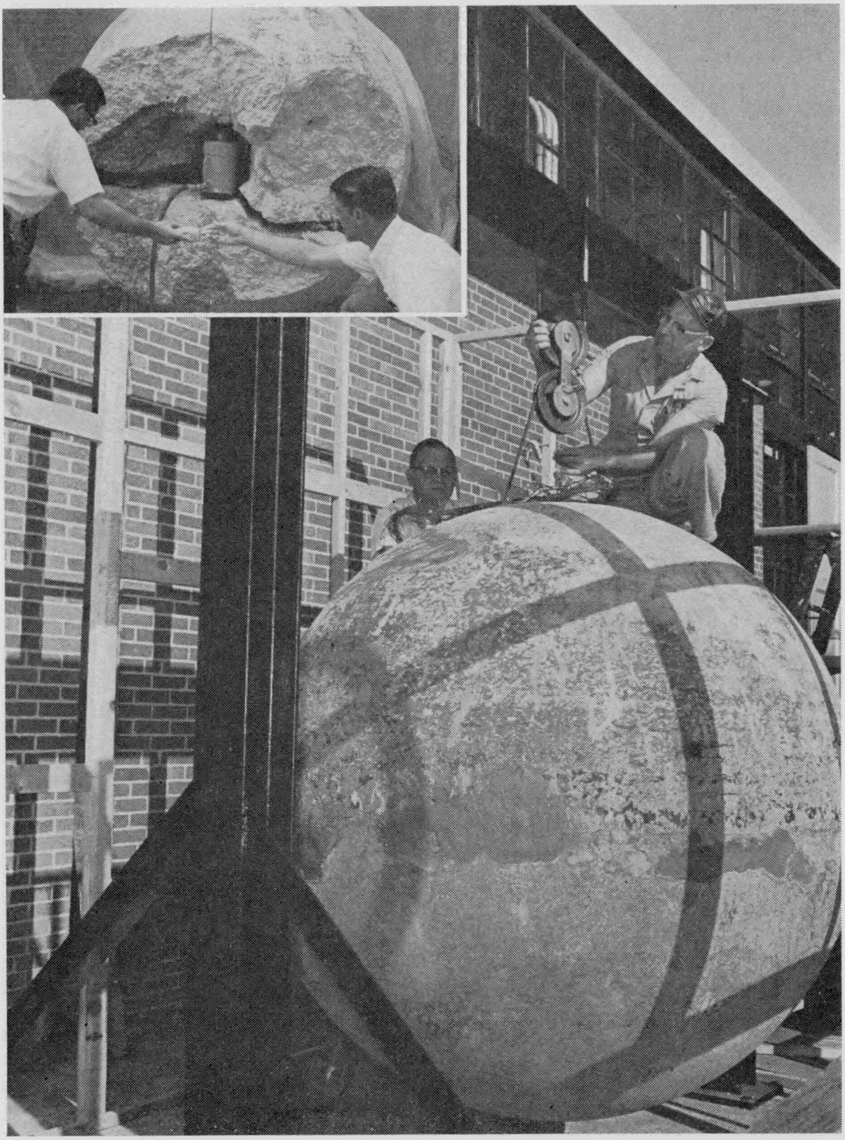
European Nuclear Energy Agency

The AEC continued its participation in joint projects with the European Nuclear Energy Agency (ENEA), including the Halden Heavy Boiling Water Reactor in Norway, the Dragon High Temperature Reactor Project in England, Eurochemic in Belgium, and the International Food Irradiation Project at Seibersdorf, Austria. Information exchanges on the peaceful uses of nuclear energy and participation in related study groups and symposia continued.

Agreements for Cooperation

At the end of 1968, the United States had in effect 33 Agreements for Cooperation in the civil uses of atomic energy. (See Appendix 6 for listing.) During the year, superseding research and power agreements with Japan and the Philippines and amendments to research agreements with Denmark and Ireland were concluded. The major purpose of the superseding agreements was to assure the supply of enriched uranium necessary to cover long term fuel requirements for the nuclear power programs of the countries involved, and to provide for toll enrichment services for the supply of enriched uranium fuel for power reactors. These agreements have a duration of 30 years. The main purpose of the two amendments was to extend the research agreements with Denmark and Ireland for 5 and 10 years, respectively. In all four, under the terms of the private ownership legislation enacted in

1964, provisions were included to permit private persons to make arrangements for the transfer, including export, of special nuclear material.



Moisture and Temperature Variations are factors of importance to the structural stability of precast concrete reactor pressure vessels. Photo shows a 6-foot diameter concrete sphere that is used to study temperature-dependent migration of moisture in precast concrete. The cutaway (*inset*) photo shows how moisture-temperature sensors are located within the precast sphere. The studies, sponsored by the European Atomic Energy Community (Euratom), are being made by Battelle Memorial Institute, Columbus, Ohio.

Information and Personnel Exchanges

Exchange of Technical Information

The United States has followed a broad policy of exchanging with other nations current technology on nuclear power. During 1968, new technical exchange arrangements were made with Denmark and Japan. More than 40 exchange arrangements continued. Those countries having an interest were kept informed on the progress of AEC-sponsored studies on the potential uses of nuclear energy in agro-industrial complexes.

Denmark. Arrangements were made for an information exchange dealing specifically with studies on radiation chemistry.

Japan. On July 15, 1968, the first meeting between the AEC Commissioners and those of the Japanese Atomic Energy Commission was

The First Formal Meeting between members of the Japanese Atomic Energy Commission (JAEC) and the U.S. AEC Commissioners was held in Washington, D.C., on July 15, 1968. AEC Chairman Glenn T. Seaborg is shown presenting a gavel and plaque made of radiation processed wood to Naotsugu Nabeshima, Japanese Minister of State for Science and Technology, at the conclusion of the meeting between the two Commissions. Shown are, *left to right:* Tsuneo Fujinami, Director, Japanese Atomic Energy Bureau; Mr. Nabeshima; AEC Commissioner James T. Ramey; Dr. Tasaburo Yamada, JAEC Commissioner; Dr. Seaborg; and AEC Commissioners Wilfrid E. Johnson, and Gerald F. Tape.

held in Washington, D.C. The members of the two Commissions agreed in principle upon the exchange of technical information on fast breeder power reactors, radiation preservation of foods, and the use of plutonium in power reactors. An agreement had been reached earlier in the year on a similar exchange on radiation chemistry.

Personnel Training Assignments

The participation of foreign nationals in the unclassified research programs at AEC facilities continues to be an important area of cooperation with Free World countries in the development of the peaceful uses of nuclear energy. This is accomplished under specific technical exchange arrangements and through the diverse opportunities made available to qualified persons to pursue individual research programs or training and to attend short term courses. The Oak Ridge Associated Universities, Inc., and the Puerto Rico Nuclear Center continued to offer short term courses in various areas of interest. Since 1955, foreign national participants at AEC facilities have numbered more than 5,400. Training in safeguards techniques is being accomplished at the AEC's safeguards training school at the Argonne National Laboratory (see Chapter 2).

Cooperation With the Soviet Union and Romania

A new Memorandum on Cooperation between the AEC and the U.S.S.R. State Committee on the Uses of Atomic Energy, was signed in Moscow on July 29, 1968. This memorandum, covering the period 1968–69, provides for the reciprocal exchange of scientific personnel and information in the field of peaceful uses of atomic energy. A similar memorandum was signed with the Romanian Committee on Nuclear Energy on November 22, 1968, which will become effective on January 1, 1969, and extend through 1970. This memorandum and that involving the Soviet Union are the only two concluded with Eastern bloc nations.

Laboratory-to-Laboratory Arrangements

The Argonne, Brookhaven, and Oak Ridge National Laboratories and the Puerto Rico Nuclear Center, have provided advice and small items of equipment to research reactor centers abroad under laboratory-to-laboratory arrangements. During 1968, such arrangements were continued with research reactor centers in the Republic of China (Taiwan), Pakistan, and Greece. Activities involving centers in Korea, Thailand, and Colombia, were continued only to the extent that previous unexpended funds were available. Initial steps were taken to establish a laboratory-to-laboratory arrangement with the National Nuclear Energy Center in Mexico.

Loan of Irradiators

The AEC increased its support of food irradiation and insect eradication programs abroad through the loan of irradiators to selected countries doing such research. Irradiators are now on loan to: Iceland, Israel, Peru, and the Organization of American States (Inter-American Institute for Agricultural Sciences, Turrialba, Costa Rica). Commitments also have been made to lend irradiators to Argentina, Chile, India, and Pakistan in 1969. In addition, a 10,000 curie source has been loaned to Venezuela for use in a food irradiator.

NUCLEAR DESALTING

There was sustained international interest throughout the year in the potential of dual-purpose nuclear power-desalting plants as a major source of fresh water and electricity. The IAEA continued to serve as a focal point for international cooperation in this field. Representatives from the United States participated in the IAEA Symposium on Nuclear Desalination held in Madrid, November 18–22, 1968.

Project Studies

A United States-Mexico-IAEA group concluded a study on the feasibility of installing a large nuclear power-desalting plant on the Gulf of California. Such a plant would be expected to produce fresh water and electric power for the arid regions of Arizona and California in the United States, and the states of Baja California and Sonora in Mexico. The study group concluded that the project would be technically feasible and recommended that further studies be undertaken on various aspects of the proposed project.

A study on the potential of nuclear powered agro-industrial energy centers in the Middle East, as a means of helping overcome the chronic shortage of water and power in that area, was begun in 1968 by the AEC through its Oak Ridge National Laboratory. The IAEA was invited to participate in the study which is to be completed in mid-1969. Technical assistance is also being provided by ORNL on a study by the Indian Government to examine the application of the energy center concept at various locations in India. The United States and Israel continued consideration of a proposed nuclear-desalting plant to provide energy and desalted water for use in Israel.

Discussions were also held with several other nations interested in nuclear desalting including Chile, Pakistan, and Spain.

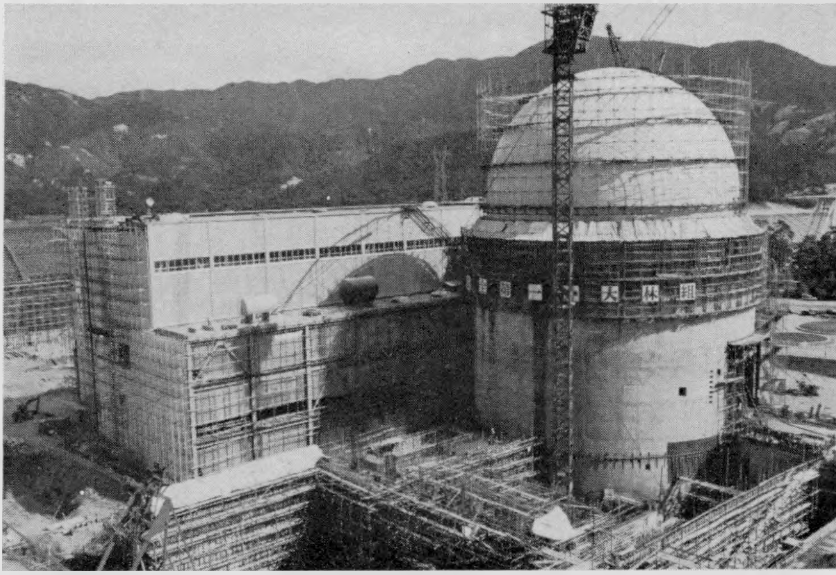
COMMERCIAL ACTIVITIES

American type power reactors continued to be the most popular reactors sold abroad. As of the end of 1968, more than 25 such systems totaling about 10 million kw., and representing an investment of over $2 billion, were in operation, under construction, or firmly programed. Additional U.S.-type powerplants are being considered by foreign utilities. The market for U.S.-type reactors is expected to increase and reflects both the recognition of the economy of U.S.-reactor technology and the attractiveness of U.S.-supplied enrichment services, including ceiling prices for those services, which are assured for the expected life of the nuclear powerplants. To further its support of use of enriched uranium abroad, the AEC adopted a new policy late in 1968 to deliver requirements for enriched uranium for periods as long as 5 years in advance of actual needs. This is expected to strengthen the contractual assurances of long term availabilty of materials given by the United States. Proposals for inventories covering even longer periods will be considered.

Table 1 sets forth the kilogram amounts of uranium-235, the bulk of which is allocated for use in power reactors under Agreements for Cooperation with countries having particular interest in enriched uranium nuclear power systems, and the megawatts of capacity corresponding to these commitments.

TABLE 1.—URANIUM-235 PROVIDED UNDER AGREEMENTS FOR COOPERATION

Country	Mwe. Capacity	U^{235} Commitment (kgs.)
Euratom (principally for Belgium, Italy, and the Federal Republic of Germany)	13,000	215,000
India	380	14,500
Japan	6,660	161,000
Norway	600	10,500
Philippines	1,000	17,500
Spain	480	8,500
Sweden	2,600	50,000
Switzerland	1,600	30,000
Total	26,320	507,000



More Than 25 American Reactors have been sold abroad for nuclear powerplants. Photo *above* shows the containment vessel of the Mihama No. 1 enriched uranium, pressurized water, 340-Mwe. nuclear powerplant under construction at Mihama, Japan. The plant will be completed by 1970, and is being built by Westinghouse. Shown *below* is an interesting view of the enriched uranium, boiling water, 400-Mwe. nuclear powerplant being built on the Tsuruga Peninsula, Japan, by General Electric. The plant is expected to be completed by 1970.

Supply of Materials Abroad

As of mid-1968, the AEC had distributed abroad—through sale and lease, and deferred payment sales—special nuclear and other materials to the approximate value of $313.3 million, resulting in revenues so far to the United States of $221.8 million. During the year, the AEC had under negotiation several contracts to provide uranium toll enrichment services for power reactors in Germany, Japan, The Netherlands, and Switzerland and for several research and test reactors in France. The AEC revenue from such contracts is estimated to be $326 million.

In 1968, the AEC negotiated the sale of 850 tons of heavy water, valued at $42 million, for use as a coolant and/or moderator in power reactors in Canada, Germany, and Sweden. Additional sales are under negotiation.

Services Provided

The United States provided chemical processing services for Canadian and Japanese reactors during 1968. There were 13 shipments of highly enriched spent research fuel to the United States in 1968. Processing services for this type of fuel continue to be available at the AEC's Idaho Chemical Processing Plant and the Savannah River S.C., plant until such services become commercially available.

The AEC continued to make available, for foreign distribution, limited quantities of the transuranium elements americium-243, californium-252, and curium-244, as sources for research purposes.

To date, the AEC has assisted the U.S. Coast Guard in the clearance of 46 U.S. ports to handle shipments of radioactive materials.

Chapter 13

INFORMATIONAL AND RELATED ACTIVITIES

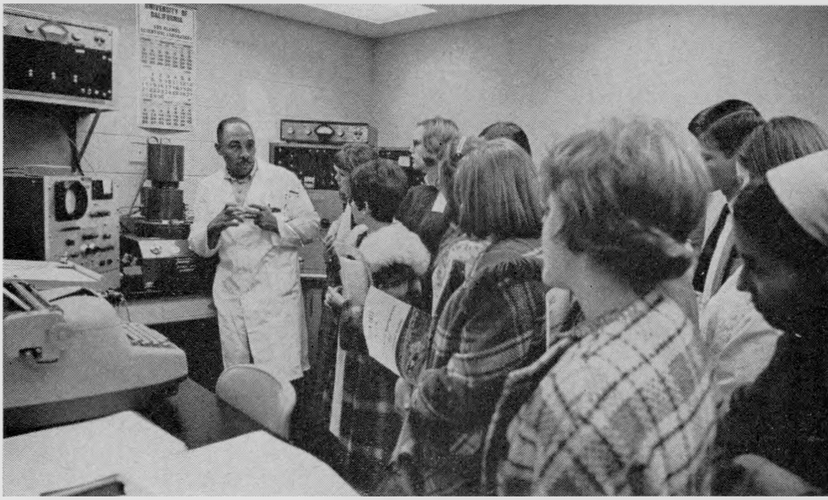
PUBLIC INFORMATION

Electronic devices are setting a rapid pace in modern society. TV-viewers, car radio listeners, movie goers, and the more leisurely news readers are inescapably plunged into the faster tempo. People of every age and wage bracket are pressed simply to keep up. The vague awareness of developments and events that used to "get by" in gentler times no longer suffices.

More and more, the individual must become informed, often with some technical precision. Specific information is both required and expected. It is not possible instinctively to understand the present environment. Nuclear energy particularly cannot be fathomed by the unaided human senses; it is above human experience. The nature of the changes the atom has brought—quite apart from man's non-nuclear advances—makes information in depth imperative.

Because of its unusual mission, the AEC is obliged to try to keep people, at home and abroad, abreast of nuclear technology and activities. This is undertaken through a wide range of technical and popular communications in the form of texts, documents, conferences, speeches, pictures, TV and films, newsclips, demonstrations, exhibits, facility tours, and student-oriented activities.

To keep up with modern techniques, the AEC public information program stresses illustration, film, and sound transcription in an effort to provide factual information to all. A number of improvements have been made in serving the public. New ideas are being placed before audiences through fresh approaches in photographic presentation of atomic energy subjects. New atomic energy films with more interesting visual and sound effects have been produced and shown widely.



As It Has Done for the Past 12 Years, the AEC again invited the Nation's youths to tour its facilities during the 121st anniversary observance of Thomas Alva Edison's birthday in February. More than 5,000 high school students visited the 14 AEC laboratories. In photo *above* a Los Alamos Scientific Laboratory (LASL) scientist explains the technique of measuring the level of contamination in radioactive wastes to some of the 700 high school students from 34 schools in five States (New Mexico, Arizona, California, Colorado, and Texas) that toured LASL. In another demonstration at LASL, a scientist uses a wrench (floating at tips of his fingers) to demonstrate the power of the magnetic field surrounding a DC plasma chamber (part of the Project Sherwood controlled thermonuclear research) to some of the high school students.

Aid to Local News Media

Explaining the operational and safety aspects of nuclear reactors and isotopic devices in nontechnical language has occupied key AEC technical and public information staff. Information has been prepared and distributed in forms more useful to the daily and weekly newspapers and periodicals. Feature stories with a lighter touch and short features on technical subjects have proved to be popular. Special interviews and briefings for news representatives have been conducted on key programs and on special occasions.

ATOMIC ENERGY FILMS

The screenings of atomic energy films by educational institutions at all levels, and by public and industrial organizations, continue to increase. The AEC's domestic film libraries and nonprofit sublibraries loaned popular and professional-level films on atomic energy for 104,313 showings. During the year, 13 new motion pictures were added to the film library system.[1] At the same time, 28 films were withdrawn as obsolete, and 85 were designated as being useful for their historical content only. AEC films were widely used on television, at international exhibits, and were circulated by AEC and USIA libraries abroad.

Film Showings

Stocked with 11,163 prints of popular and professional-level films during 1968, the AEC's 10 domestic film libraries and nonprofit sublibraries loaned films which were viewd by an estimated 4,350,000 persons in public schools, institutions of higher learning, industrial organizations, scientific and engineering groups, service clubs, and other community groups.

[1] Descriptions of films available for public showings are included in the "Popular-Level" and "Professional-Level" film catalogs available, without charge, from Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545. The AEC's domestic film libraries located at the following AEC offices serve requests from the indicated States: *Washington, D.C.:* Delaware, District of Columbia, Maryland, Virginia, West Virginia, and Canada; *New York, N.Y.:* Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; *Aiken, S.C.:* Alabama, Florida, Georgia, North Carolina, and South Carolina; *Idaho Falls, Idaho:* Idaho, Montana, and Utah; *Berkeley, Calif.:* California, Hawaii, and Nevada; *Grand Junction, Colo.:* Colorado, Kansas, Nebraska, and Wyoming; *Argonne, Ill.:* Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, North Dakota, Ohio, South Dakota, and Wisconsin; *Oak Ridge, Tenn.:* Arkansas, Kentucky, Lousiana, Mississippi, and Tennessee; *Albuquerque, N. Mex.:* Arizona, New Mexico, Oklahoma, and Texas; and *Richland, Wash.:* Alaska, Oregon, and Washington.

International Aspects

Loans of more than 3,000 motion pictures, largely on a professional level and shown to 155,000 people, were made from AEC liaison offices in London, Tokyo, Brussels, and Buenos Aires, the latter two libraries supplying French and Spanish versions of many of these films. The use of AEC films by foreign scientific, industrial, and educational organizations has increased during the past year with Australia, The Netherlands, and Israel heading the list.

AEC motion pictures were used in "Atoms in Action" Nuclear Science Demonstration Centers in Caracas, Venezuela; Taipei, China; Seoul, Korea; and Cordoba, Argentina. Foreign versions of AEC films were provided by the U.S. Information Agency (USIA) to make French, Spanish, Dutch, Hebrew, Urdu, Portuguese, and Arabic versions of selected titles. These versions were used by AEC foreign exhibits, the International Atomic Energy Agency (IAEA) for worldwide film loans, and U.S. Embassies.

In addition, foreign as well as English-language versions were supplied to the National Science Film Library of Canada in Ontario, the American Film Library at The Hague, the IAEA Film Library in Vienna, to the USIA service offices in Stockholm and Brussels, to the U.S. Agency for International Development (AID) Film Libraries in Mexico City, Paris, and Washington, D.C.

Two AEC films—"Guardian of the Atom" and "The Day Tomorrow Began"—were selected for international Golden Eagle Awards by the Council on International Nontheatrical Events (CINE). In all, 49 AEC films were entered in 23 international competitions.

Atomic Energy on Television

AEC films were used widely on domestic and foreign television. U.S. audiences estimated at 23 million viewed AEC films through 276 reported showings on educational and commercial TV channels.

Many network and individual stations were provided footage, photographic, and other assistance in covering atomic energy activities. Several specials on subjects such as the Gasbuggy experiment and radiation surveys at Bikini were produced and released for use on television newscasts.

On various AEC activities, British, Japanese, and German TV producers were supplied with stock footage, information, and filming opportunities.

Atomic Energy on Radio

The first in a series of packaged radio programs has been produced and offered to commercial and educational broadcasting stations in the United States and Canada. Entitled "Let's Talk About the Atom," it consists of 12 10-minute interviews with leaders in science who discuss the beneficial uses of atomic energy.

Atomic Energy Photos and Slides

An AEC color slide and transparency library, representing a broad range of Commission activities, was developed, and a collection of black and white news photographs was updated. Slides were made available to science teachers and to AEC and contractor speakers as visual aids. Color transparencies and black and white photographs were supplied on request to the magazine and news media, educational publishers, science writers, exhibits, and for use in reports.

TECHNICAL INFORMATION

The objective of AEC's technical information programs is to channel scientific and technical information generated in worldwide nuclear research and development to those who have need of it (scientists, engineers, educators, students, and the general public), in forms most readily assimilable by the respective audiences. AEC is approaching this task on both a national and an international basis.

INFORMATION SYSTEMS AND SERVICES

Long term international cooperation in the sharing of nuclear information, with participating nations bearing a fair portion of the responsibilities and costs, now seems to be a firmly established principle. The AEC is taking a leading part in the development of systems to support this principle.

International Nuclear Information System

Progress was made in 1968 toward the development, under International Atomic Energy Agency (IAEA) auspices, of an international nuclear information system. An IAEA study team, which included AEC staff as well as members from other leading industrial countries, completed a 4-month study which outlined the main features of the system, estimated its costs, described needed equipment, and indicated the media in which the system's products would be communicated. This report was reviewed by a group of experts at a meeting in Vienna in October. The group recommended that the IAEA Board of Governors consider implementing the system beginning in 1970.

The basic proposal is that each country would survey its own national scientific literature, identify items which fall within the subject scope of the system, and supply bibliographic descriptions, abstracts and subject indexing terms to the IAEA. The IAEA, in turn, would merge the data received and make available on magnetic tape copies of a complete file which each member state would be able to use in supplying nuclear information services. The IAEA would also supply a periodical categorized listing of all items reported to the system and, on request, micronegative copies of report literature and abstracts.

Bilateral Agreements

The AEC continued its arrangements with Canada, the United Kingdom, Australia, Japan, Sweden, Norway, and Denmark, whereby each of those countries supplies English-language bibliographic citations and abstracts of its significant nuclear literature for use in the AEC semimonthly journal, "Nuclear Science Abstracts." Formalization of a similar arrangement with the European Atomic Energy Community (Euratom) was discussed. AEC laboratories are also exchanging reports on controlled thermonuclear research with laboratories in the Soviet Union. Soviet reports deemed of special interest to United States programs are translated and distributed by the AEC.

Distribution of AEC Reports Abroad

As an economy measure, intial steps were taken to reduce to one per country the number of depository libraries and other institutions abroad receiving free distribution of AEC reports. The recipient institution is being designated by the respective foreign governments.

Specialized Information Centers

With AEC support a Particle Data Center was established at Lawrence Radiation Laboratory, Berkeley, Calif. There are now 27 specialized information and data centers supported wholly or in part by the AEC. (Listed in Table 1, Appendix 7.)

Support of Conferences

The AEC supports scientific and technical conferences related to the peaceful uses of atomic energy in the belief that such meetings provide one of the best means available for keeping scientists informed about current work in their respective fields.

During 1968, the AEC contributed support to 11 conferences convened by United States scientific and technical organizations and also coordinated United States participation in 12 IAEA-sponsored conferences.

Publishing Activities

Nuclear Science Abstracts

The AEC's semimonthly journal *Nuclear Science Abstracts* (NSA) abstracted and indexed some 53,000 items of the world's nuclear literature during the year.[2] It is noteworthy that more than half of the items represent literature from countries other than the United States.

Scientific Books and Monographs

The AEC sponsors the preparation of scientific texts, reference books, and monographs to communicate the results of nuclear research to the scientific and academic communities and to the general public. Outstanding among the AEC-sponsored book publications of 1968 (listed in Table 2, Appendix 7) was a compilation on Meteorology and Atomic Energy. This joint undertaking of the AEC and the Environmental Science Services Administration (formerly the U.S. Weather Bureau) contains information important in planning the safe location of nuclear powerplants.

Educational Literature

Seven new booklets were added to the AEC's "Understanding the Atom" series bringing the total to 51. (See Table 3, Appendix 7, for complete listing.) Total distribution since the series was inaugurated

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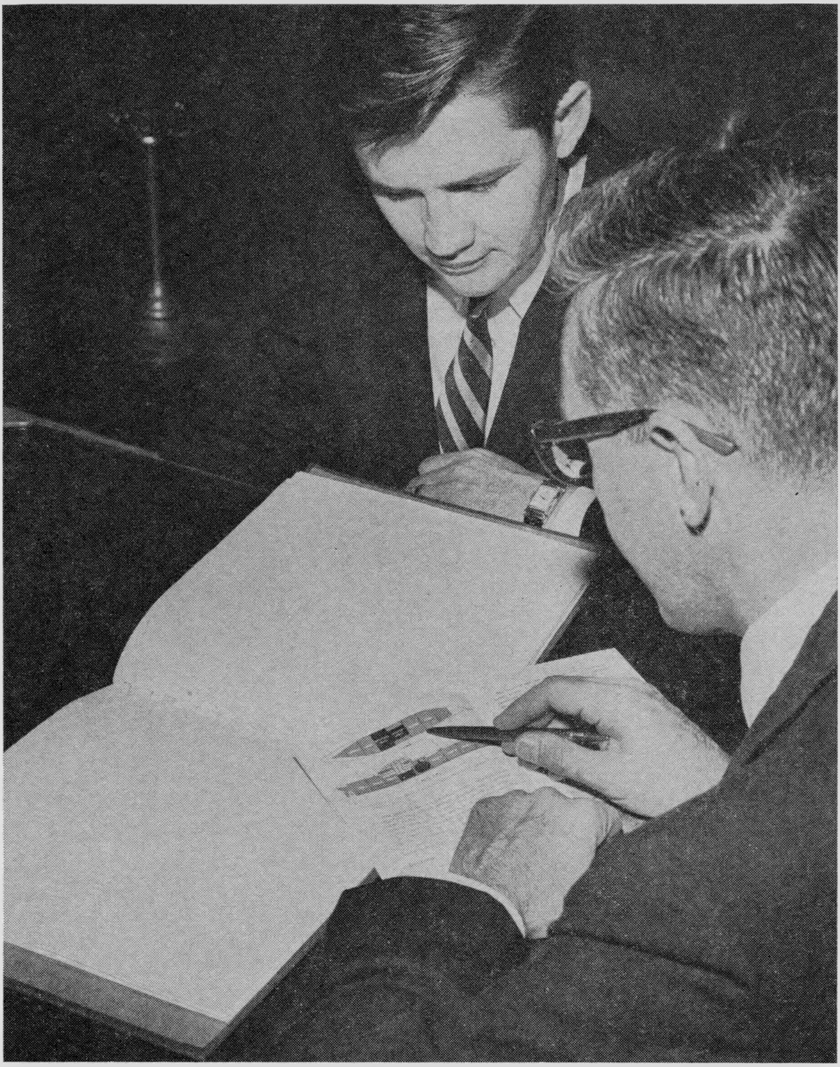
[2] NSA is available to the general public on a subscription basis from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, as follows: For the 24 regular issues, $42.00 domestic, $52.50 foreign. A single issue costs $1.75 domestic, $2.19 foreign.



The Booklet "Nuclear Power and Merchant Shipping" Was Printed in Braille during 1968, and others in the educational series will be converted later. The AEC's Technical Information Extension at Oak Ridge, Tenn., is currently cooperating with the American Printing House for the Blind, Inc., at Louisville, Ky., to make the booklets in AEC's "Understanding the Atom" series available for printing in Braille. Photo shows the larger Braille version of the booklet being compared with the standard printed version. Under an agreement with the Printing House, the AEC paid for production of the Braille printing plates, and the Printing House printed, bound, and distributed the book to various schools for the blind throughout the United States.

in 1962 has passed six million copies. Plans are underway to have some of the booklets printed in braille and recorded for use by schools for the handicapped.

Technology Transfer

AEC seeks to assist the use, by industry and by State and local goverments, of technology developed in its research and development programs. Business-oriented summaries of technological innovations have been issued in cooperation with NASA. In 1968, more than 70 "*AEC–NASA Tech Briefs*" were issued. The total number of such summaries now available is about 240.[3]

A new series of "*AEC–NASA Technology Surveys*," which are state-of-the-art summaries in specific areas of industrial interest, was initiated in 1968. Eight volumes were issued in this series.[4] (Listed in Table 4, Appendix 7.) In addition to publicizing available technology, the AEC is providing consulting services through its contractors, permitting the use of AEC facilities, and permitting specialists from industry to work at AEC sites to learn new processes and techniques. These services are furnished only when not available commercially and usually are provided at cost.

A recent example of an AEC-developed innovation that has been transferred to industry is a phase-sensitive eddy current instrument used for the nondestructive testing of flaws in materials. It has greater sensitivity and is more compact than other instruments available for this purpose. Oak Ridge National Laboratory, which developed the instrument originally for the testing of reactor fuel elements, has assisted in adapting it for use by other Federal agencies. It is now being produced and marketed commercially.

DEMONSTRATIONS AND EXHIBITS

Exhibits and live demonstrations continue to be effective means for disseminating technical information to professional, student, and general public audiences. Highlights of 1968 in the AEC exhibits program included: (*a*) five major presentations abroad, (*b*) addition of several

[3] The "AEC-NASA Tech Briefs" are available at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. 22151. The annual subscriptions, by category, are as follows: electrical (electronic), $6.00; energy sources, $2.50; materials (chemistry), $5.00; life sciences, $2.50; mechanical, $6.00; all categories, $20.00.

[4] The surveys are available, at $3.00 each, from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.

States to the number jointly sponsoring secondary school lecture-demonstrations, and (*c*) continued progress in work on the nuclear science center at the New York City Hall of Science.

Presentations Abroad

Almost half a million viewers and participants visited AEC overseas presentations during the year. This included a special exhibit in Mexico City in addition to the month-long "Atoms-in-Action" Nuclear Science Demonstration Centers in Taipei, Taiwan; Seoul, Korea; Caracas, Venezuela; and Córdoba, Argentina.

"Atoms-in-Action" Centers

A feature of the "Atoms-in-Action" presentation in Taipei (April 12–May 12) was the use of a scanning device for diagnosis of liver cancer in more than 200 patients. American medical specialists participated with Chinese physicians in a medical seminar on this disease which is extremely prevalent in Taiwan.

During the exhibit in Caracas (April 18–May 19), extensive use was made of the exhibit's gamma facility for studies in radiation preservation of important local food products, for genetic studies leading to possible improvements of other foodstuffs, and for experiments on control of insect pests.

Argentina became the first Latin American nation visited a second time by "Atoms-in-Action" when the Demonstration Center was presented in the university city of Córdoba (October 18–November 17). Despite widespread student unrest which reduced attendance by the general public, all scientific and technical research and training programs offered by the Center enjoyed full participation by the Córdoba area's professional community. The new science classroom programs for high school students and their science teachers operated at capacity throughout the presentation.

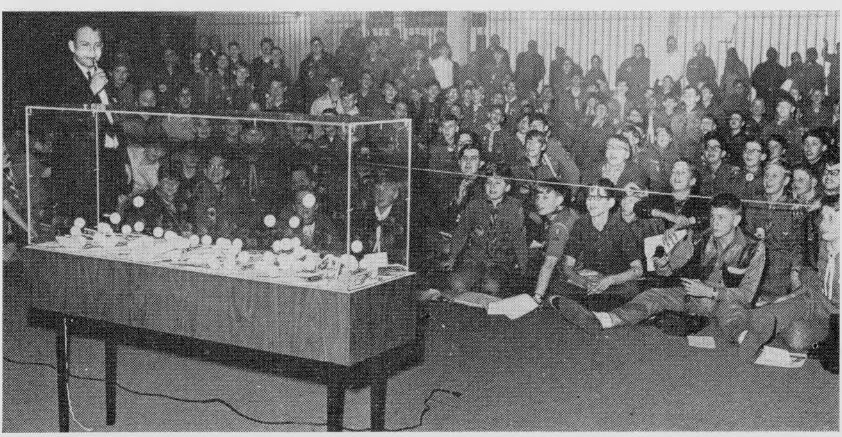
During the "Atoms-in-Action" presentation in Seoul, Korea (September 9–October 8) an intensive program of lectures on nuclear medicine was received enthusiastically by physicians and medical research workers throughout the country. Since Korea lacks any frozen foods and enjoys little refrigeration, a number of irradiation experiments were aimed at better preservation of local foodstuffs. These were conducted in cooperation with the host country's colleges of home economics, thus involving in the scientific program an unusually large number of women students.

In 1969, it is planned to operate "Atoms-in-Action" centers in Manila, Philippines; Sao Paulo, Brazil; and Bucharest, Romania.

Other International Exhibits

A special AEC exhibit entitled "A New Abundance of Energy" was shown at the National Polytechnic Institute in Mexico City (October 5–December 2) as part of the cultural program held in conjunction with the Olympic games. The exhibit explained in nontech-

At the End of Summer, as High Schools Reopened Their Doors, a fleet of vehicles (*above*) loaded with "This Atomic World" lecture-demonstration equipment was ready to leave Oak Ridge, Tenn., for 1-day visits to over 2,500 schools. A nuclear-science trained exhibits manager drives each vehicle, presents lecture demonstrations, and holds classroom sessions in each school. Ten units of the program were operating in 1968 under joint-sponsorship contracts with State universities and other organizations in Florida, Kentucky, Louisiana, New York (2 units), North Carolina, Oklahoma, Oregon, Texas, and Wisconsin. Nine other units are operated for the AEC by Oak Ridge Associated Universities (ORAU). The AEC's Cincinnati Area Office and two AEC contractors—ORAU and the General Electric Co.—cooperated to present a special "This Atomic World" program in the Cincinnati area through which some 450 Boy Scouts earned their Atomic Energy Merit Badge. *Below*, the exhibits manager explains with ping pong balls and mouse traps the principle of nuclear fission to the group which met 1 night a week for 6 weeks in the Cincinnati Science Center to earn their badges. It was the largest group of Scouts ever to receive a single merit badge during ceremonies April 19 in Cincinnati.



nical terms the worldwide benefits obtainable from various peaceful uses of nuclear energy.

An exhibit on water needs and the prospects of nuclear desalting for meeting them was shown during November and December in several of the major cities in Pakistan.

Presentations in the United States

AEC demonstrations and exhibits in the United States are carried out with the assistance of the Oak Ridge Associated Universities. They attracted more than 7 million viewers during 1968.

Secondary School Demonstrations

The lecture demonstration program "This Atomic World" was presented during the year to a record 3 million students and their teachers in some 3,000 secondary schools in 33 States including Hawaii, which was visited for the first time. At the current level, the AEC estimates that it is now halfway to its goal of being able to reach each high school graduate with this presentation at least once during his term in high school.

There were 14 "This Atomic World" units in service when schools closed in the spring; 19 when they reopened in September. A prime reason for the increase was further expansion of the cooperative program with State organizations begun in 1966. Under this arrangement, the AEC supplies the demonstration equipment, the transport van, and the training for the teacher-demonstrator, while the State organization hires the demonstrator, pays his salary and other expenses, and schedules presentations within the State. (Participating organizations during the 1968–69 school year are listed in Appendix 7, Table 5.) Two universities which were participating sponsors reported significant gains, against present trends, in admissions or enrollments in technical fields, including nuclear science. University spokesmen attributed the gains in part to their association with the AEC program.

One "This Atomic World" unit was used during the summer to reach underprivileged children in Philadelphia. In cooperation with the Franklin Institute and the Philadelphia Department of Recreation, it staged demonstrations in parks, in recreation centers, at swimming pools and in the streets. There was much active participation by the children.

Oak Ridge Museum

Attendance at the American Museum of Atomic Energy-Oak Ridge Hall of Science, was 42,973 in August, the highest monthly figure in the museum's history. On August 6, there was a 1-day record of 2,184 including visitors from 11 foreign countries.

Circulating Museum Exhibits

The large manned exhibits developed specifically for extended museum engagements were booked solidly during the year and were visited by some 1,100,000 persons.

The popular children's exhibit, "Atomsville, U.S.A.," was at the New York Hall of Science for the entire year. "Life Science Radiation Laboratory," which features actual demonstration of biological experiments, was shown in Seattle, Wash., at the Chicago Museum of Science and Industry, and at the Franklin Institute in Philadelphia. The major general exhibit, "Radiation and Man," was presented in St. Louis, Columbus, and Milwaukee. Each of these exhibit programs served as the base for experimental programs that reached out from the museum into the community via television appearances, civic club lectures, teacher workshops, radio interviews, and Sunday-supplement articles. Such activities reached audiences totaling several million above tabulated exhibit attendance.

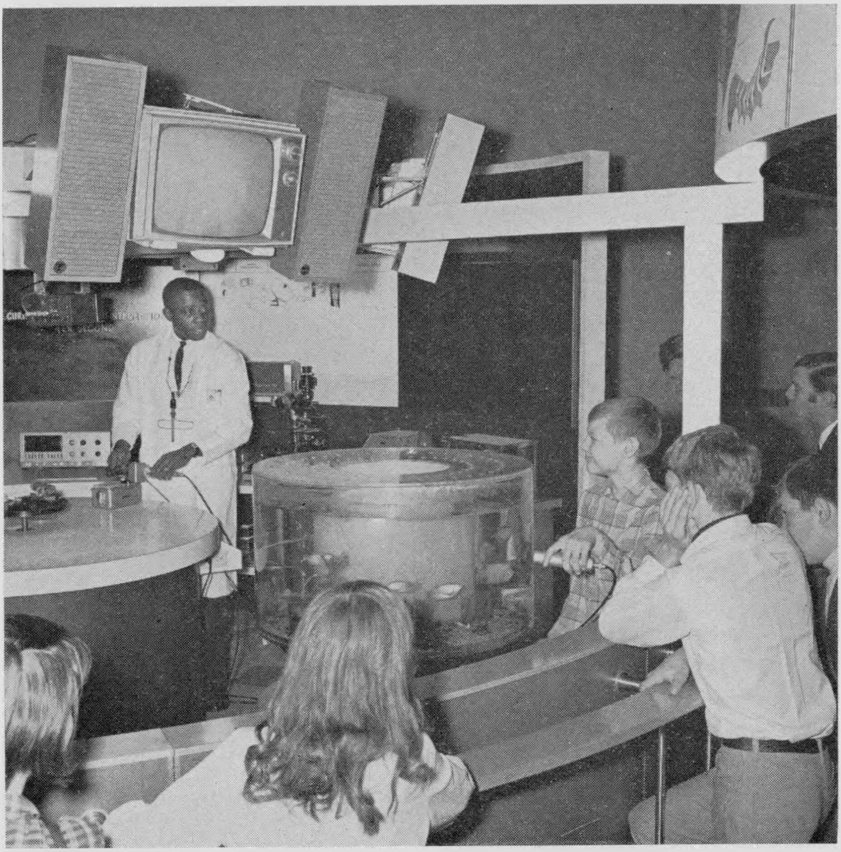
INFORMATION DECLASSIFICATION

AEC classification policy is continuously reviewed and revised to keep pace with the changing needs of national welfare and of the national defense and security. A proper balance is thus maintained between the declassification and release of information and continued control of project information involving national security. Assurance that AEC policy is well geared to the present and the foreseeable future was obtained during the year as a result of a comprehensive classification study of all AEC programs.

Classification Study

A panel of classification experts, including the Committee of Senior Reviewers (see Appendix 2 for list of members), was charged with making a study and recommending to the Commission any actions found necessary for bringing classification policy wholly into consonance with the times—even to the extent, if necessary, of formulating an entirely new policy and classification program.

The panel considered the informational needs for progress in basic science, industry, biology and medicine, agriculture, and other areas important to a strong healthy future, and also the need for withholding information which could further the proliferation of nuclear weapons or jeopardize the U.S. national defense position. To aid in its study and deliberations, it solicited the views of well-informed representatives of industry, the Government, and the AEC itself.



Which Fish in This Aquarium Has Been Tagged With a Radioisotope? Youngsters visiting the Chicago Museum of Science and Industry "fish" with a Geiger counter as an Oak Ridge Associated Universities exhibits manager explains how scientists use the same principle in ecological studies. The popular display is part of the AEC's "Life Science Radiation Laboratory," a circulating museum exhibit which spent several months at the Pacific Science Center in Seattle and at the Franklin Institute in Philadelphia in addition to the Chicago presentation. The "laboratory" also includes live animals and plants which the exhibits manager displays as actual examples of radiation effects on living organisms.

The panel affirmed in its final report the soundness of the changes which had been made through the years and cited the additional areas of information which it believed could be safely declassified, thus bringing up to date the line of balance between strengthening the national welfare and protecting the national security. In accordance with the panel's recommendations, the declassified areas now include all information, with a few specific exceptions, regarding Army compact reactor technology, zirconium hydride-moderated SNAP reactors, and isotopic heat sources.

Documents Declassified

Approximately 10,000 documents in the newly declassified (see above) and other areas were declassified during the year and made available to science and industry.

Access Permits

The AEC's Access Permit Program continues to provide classified information to individuals for civilian applications of atomic energy.

On November 30, 1968, there were 375 Access Permits in effect: 304 for access to Secret Restricted Data and 71 for access to Confidential Restricted Data, as compared to 314 for Secret, and 81 for Confidential a year earlier.

PATENT INFORMATION

Abstracts of AEC-owned patents available for licensing are published in technical journals and officially announced [5] through the AEC public information program.

1968 Issuances

During the period November 21, 1967, to November 19, 1968, the U.S. Patent Office issued 231 U.S. patents to the AEC. The AEC now administers 4,085 unexpired U.S. patents which are available for licensing. The total portfolio of AEC-owned foreign patents in more

[5] Listings published as AEC public announcements during 1968: No. IN–857 (U.S. Patents), March 7; No. IN–859 (U.S. Patents), February 15; No. IN–867 (Canadian Patents), May 10; IN–870 (U.S. Patents), June 5; No. L–215 (U.S. Patents) September 11; No. L–216 (French Patents), September 11; No. L–260 (British Patents), November 12; No. L–261 (Australian Patents), November 12; No. L–262 (U.S. Patents), November 12; available from Division of Public Information, U.S. AEC, Washington, D.C. 20545.

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than 15 foreign countries now numbers 3,940 which is an increase of 426 during this period.

The AEC granted 162 nonexclusive licenses on Government-owned patents and patent applications. Contractors have retained 28 non-exclusive licenses in addition to those granted by AEC. In 44 patents AEC contractors have retained exclusive licenses in fields other than atomic energy. The title and rights in 56 patents are vested in the contractor, subject to a nonexclusive license in the AEC for governmental purposes.

Patent Applications

The Commissioner of Patents referred 602 privately owned U.S. patent applications in the atomic energy field to the AEC under the provisions of Section 152 of the Atomic Energy Act of 1954, as amended. The AEC filed 54 directives with the Commissioner of Patents with respect to the question of rights during the year, bringing the total number of directives filed under Section 152 to 248. The AEC has acquired rights in 130 Section 152 applications, and in 89 cases the directives were withdrawn without acquisition of rights after completion of investigations, and 2 cases were abandoned. Some 27 applications are pending.

Chapter 14

NUCLEAR EDUCATION AND TRAINING

EDUCATIONAL ASSISTANCE

People with different technical backgrounds and skills continue to be needed for building and applying nuclear knowledge. As needs change, the AEC must keep pace with these changes, try to anticipate them, and help assure the national capability to meet them.

The AEC's nuclear training programs, therefore, feature: (*a*) educational assistance in graduate education in nuclear specialties; (*b*) a variety of educational and training programs involving special nuclear equipment and technologies at AEC laboratories; and (*c*) matching grant assistance for nuclear equipment to academic institutions. Most of these activities entail coordination or cooperation with other Federal agencies, AEC contractors, academic institutions and associations, professional nuclear associations, and industrial groups.

GENERAL TRAINING ACTIVITIES

Although the overall level of AEC's training activities did not change much from 1967 to 1968, certain developments and changes, consonant with the dynamic nature of the field, occurred.

Used Equipment Grant Program

Procedures were established whereby nuclear equipment, no longer needed for AEC contractor operations, is made available by grants to institutions having life sciences, physical sciences, or engineering curricula. This enables recipient colleges and universities to upgrade and expand their educational programs in the nuclear field.

AMU-AUA Reorganization

The educational programs administered for the AEC by the Associated Midwest Universities have been incorporated in the policy responsibilities of the Argonne Universities Association. Operational responsibilities rest with the Argonne National Laboratory. This will permit a closer relationship between the educational community and the research programs at the Argonne National Laboratory. An early result is the formation of the Argonne Center for Educational Affairs at the laboratory.

Radiography Course Materials

Manuals for an 80-hour technician training course on industrial radiography were issued jointly by the AEC and the U.S. Office of Education. The 3-volume set comprises a source manual, an instructor's guide, and a student exercise book.[1]

Negro School Assistance

Brookhaven National Laboratory, with AEC's encouragement, received a grant from the National Science Foundation to bring into the laboratory six selected students and faculty from several predominantly Negro colleges in the South for an academic year of training and research experience. Six students participate each semester and two faculty members for an academic year (see illustration on p. 19 of "Introductory" chapter).

Graduate Centers

There has been a continued growth of interest in graduate centers located in or near AEC laboratories in Richland, Wash., Los Alamos, N. Mex., Livermore, Calif., and Oak Ridge, Tenn. These centers function primarily as a service for AEC-contractor employee development programs, focusing on job-related subjects in the nuclear field. Another important part of the growing contractor-university relationships seen at these centers is the greater opportunity for laboratory personnel to add to their strengths through teaching activities. They also enable the temporary exchange of personnel in research activities.

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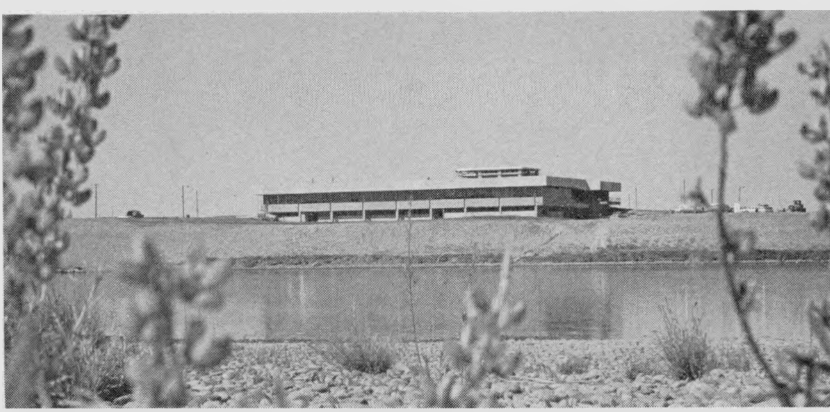
[1] Available for purchase from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

Utility Manpower Training Study

The AEC, the utilities, and the nuclear reactor manufacturers are concerned with the problem of assuring the adequacy of trained personnel to operate safely the large number of nuclear power reactors planned for the 1970's. The AEC staff is completing a study of the availability and nature of training programs provided by utility organizations, reactor manufacturers, nuclear consultants, institutions of higher education, and Governmental entities. These results and other information were being incorporated, at year's end, in a broad utility training guide for technical manpower staffing at both corporate headquarters and nuclear power stations. Publication of the guide is expected early in 1969.

Current training programs for utility personnel are designed primarily by reactor manufacturers and nuclear consultants, with assistance from universities possessing teaching and research reactors. The AEC's role is mainly as the compiler and distributor of informational material and the provision of work opportunities at AEC sites for reactor supervisors and health physicists.

One reactor manufacturer established a new facility making major use of simulators for training people who require AEC operating licenses. Other manufacturers have announced plans for similar facilities. These new simulator-based facilities may help alleviate the need



This New Richland, Wash., Center for Graduate Study was completed in mid-1968 near the AEC's Hanford Works in southeastern Washington State. The center is operated by the University of Washington and Washington State and Oregon State Universities in cooperation with the AEC. The $1.5 million structure was financed by State funds, grants from Hanford contractors, and the AEC. Until completion of this classroom-office building on the Columbia River, classes were meeting in temporary quarters, including secondary schools throughout Richland.

for facilities to meet the training load for reactor supervisors and reactor operators (see Chapter 5, "Reactor Development and Technology").

The AEC's continuing interaction with the expanding nuclear power industry was evidenced by the opening of a safeguards school at the Argonne National Laboratory, where training in reactor fuel accountability techniques is accomplished (see Chapter 2, "Nuclear Materials Safeguards").

AEC–CONTRACTOR PROGRAMS

Employee development programs of AEC contractors assist and encourage educational growth while working. The rewards are to be found in better job performance and higher rates of pay. At the college level, more than three-fourths of the courses taken are in scientific and technical fields. A survey has indicated that some 6,000 contractor employees annually receive some 600,000 hours of college level training. The number of employees participating may be usefully compared with the 39,500 scientific, technical, and professional employees of AEC contractors.

Technical Scholarship Program

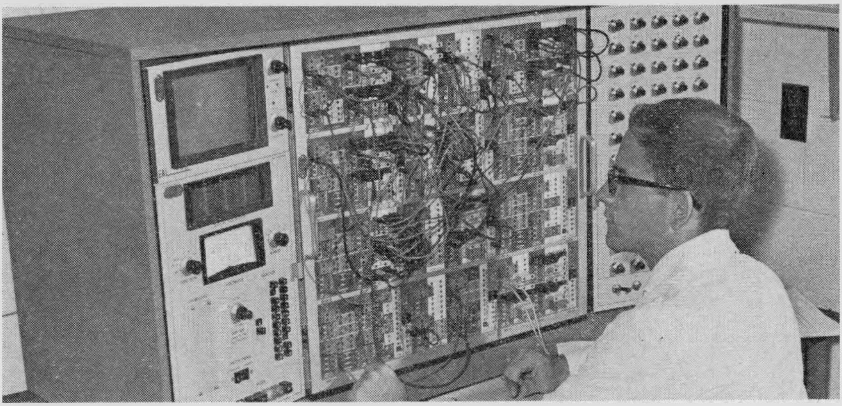
The technical scholarship program, designed to assist selected AEC-contractor technicians to complete the remaining 1- or 2-year periods of their undergraduate study, has experienced 2 academic years of operation. All the initial appointees have earned their bachelor's degrees and have returned to their laboratories in full professional capacities. Altogether, 43 scholarship appointments have been made in the program and 14 appointees have received degrees.

Summer Employment

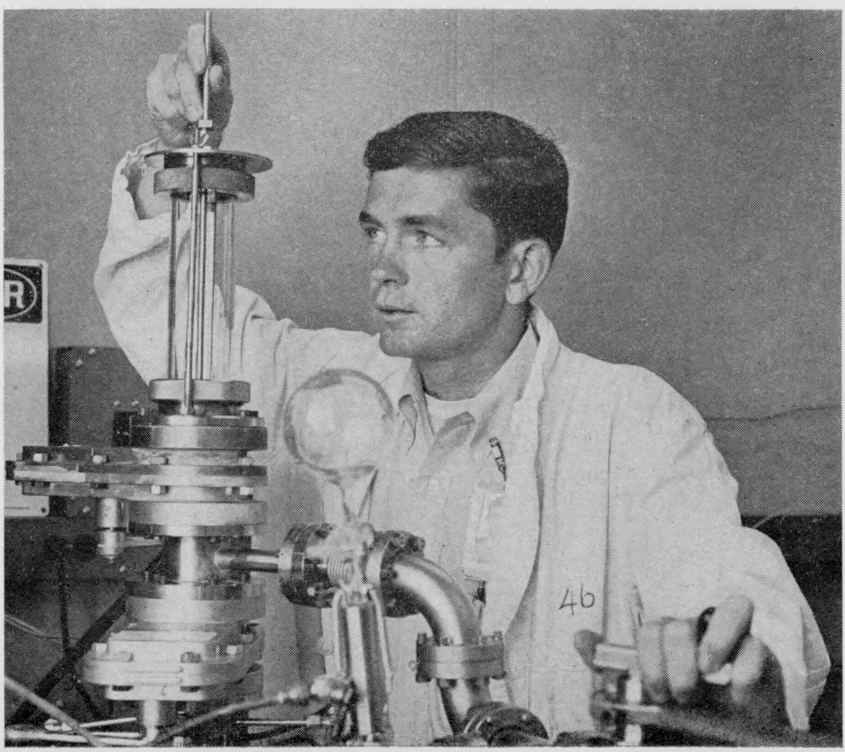
Summer employment opportunities are provided by AEC contractors. The work experience for faculty and students involves technical duties which build familiarity with plant and laboratory nuclear operations. Approximately 2,000 faculty and students were employed by AEC contractors during the summer.

COLLEGE AND UNIVERSITY PROGRAMS

The AEC fellowship program seeks outstanding students who are U.S. citizens to pursue education in specialties within nuclear science and engineering, or health physics. A very limited number of post-



Assignments Given to Summer Students employed by AEC contractors not only fit in with their chosen field of study, but also have a practical value. In photo *above*, a student from New College, Sarasota, Fla., is patching an analog computer during an experiment to fit a set of hematologic (blood) values to a mathematical model during his assignment to the Medical Division of Oak Ridge Associated Universities. In photo *below*, a graduate student from the University of California at Berkeley, is shown working at the Los Alamos Scientific Laboratory's Reactor Division. He was one of 86 graduate students employed at the Los Alamos Scientific Laboratory during the summer of 1968. In addition, the LASL summer student program included 52 Youth Opportunity Program participants and 138 students working as summer replacements.



doctoral fellowships is given in nuclear fields to advanced scientists and engineers headed for teaching careers, and to medical doctors for specialized training to cope with injuries and disease arising from radiological accidents or radiation overexposure.

As of November 1968, fellowships, including extensions, were awarded as follows: nuclear science and engineering 223; traineeships 137; laboratory graduate fellowships 129; postdoctoral fellowships 40; health physics fellowships, 72; and industrial medicine fellowships 8. Since the beginning of the AEC program over 2,400 graduate fellowships and some 200 postdoctoral or post-M.D. fellowships have been awarded.

Institutes

The AEC and the National Science Foundation sponsor institutes at universities and AEC laboratories on radiobiology, nuclear physics, isotope technology, and radiation biochemistry for over 700 high school and college science teachers.

Summer sessions of 2 to 10 weeks were held at 47 colleges, at Argonne National Laboratory, and at the Oak Ridge Associated Universities (ORAU). Five institutes were held to enable science teachers to obtain training at evening and weekend classes throughout the school year. Institutes providing a full year of graduate study were held at two universities and at Oak Ridge. Eight faculty participation institutes were held at eight colleges.

Equipment Grants and Services

As a part of its program to help assure an adequate flow of nuclear-trained people, the AEC granted $500,000 on a matching fund basis to 51 colleges and universities for the purchase of laboratory equipment for graduate level instruction in the nuclear aspects of the physical sciences, engineering, and life sciences.

In addition to the matching fund equipment grant program, reactor fuel assistance agreements totaling $232,000 were approved during the year to six academic institutions, for uses confined to education and education-related research. These agreements were principally for fuel element fabrication for both initial and replacement loadings. Also, a total of $36,000 was provided to 30 educational institutions for the purchase of radioactive source materials.

Academic Research Training

AEC-sponsored research under contracts with colleges and universities is primarily designed to extend nuclear knowledge in the physical and life sciences. However, an important benefit in training of

Students at Oregon State University are shown preparing to remove an irradiated sample from the university's TRIGA reactor. Fuel for this teaching and research reactor was provided by the AEC. This reactor is licensed for 250 kilowatts (kw.) steady power and 1,200,000 kw. in the pulsing mode. Other university TRIGA reactors are licensed for up to 1,000 kw. steady power and 2 million kw. pulses.

graduate students working for the principal investigators is also realized. During the year, there were about 2,400 graduate students employed in physical science research and 2,000 in life science research.

AEC LABORATORY PROGRAMS

Next to the pragmatic results of research at AEC laboratories, the most important product is training. On-the-job training, whether for permanent, temporary, or part-time employees, has strengthened the scientific manpower base in the atomic energy field. Training in use of specialized nuclear equipment and techniques at AEC laboratories has had a broadening benefit as personnel have moved to industry, other research organizations, medical and academic institutions. Training in safeguards techniques is being accomplished at the AEC safeguards training school at Argonne National Laboratory (see Chapter 2).

Graduate Student Training

For the past several years, the number of graduate students directly employed in research at AEC laboratories has remained at a rather constant figure—about 1,100 a year. In addition, special laboratory graduate fellowships or temporary employment of graduate students provide opportunities for a small number of persons to work on their master's or doctor's thesis at the laboratory. Two national laboratories, Argonne and Oak Ridge, furnished facilities for graduate work in engineering through practice schools.

Other AEC laboratory programs range from special laboratory experiments and faculty workshops in nuclear science and engineering to what might be called continuing education at the graduate level in the form of symposia, meetings, and lectures. The unique equipment and techniques available at AEC laboratories strongly complement the joint AEC-academic effort in nuclear training. During the year a wide variety of these programs benefited some 95 undergraduate and 76 graduate students and 201 faculty.

Undergraduate Training

Besides summer employment of undergraduates, there is a radiation protection techniques training program whereby 20 students from Idaho State University at Pocatello receive classroom, laboratory, and field instruction leading to a certificate of proficiency. Completion of 2 academic years and 2 summers in the training program at the

National Reactor Testing Station is required for certification. Other undergraduate honor students received college credit for a semester of study and research at Argonne. The three Oak Ridge-based mobile laboratories visited, upon request, some 45 small colleges to give 2 weeks' special training to faculty and students and others in basic radioisotope techniques. Student experiments at Argonne include over 1,000 students annually under primary direction of their own faculty.

Puerto Rico Nuclear Center

The graduate-level nuclear research and training programs in the physical and life sciences at the AEC's Puerto Rico Nuclear Center (PRNC) were continued in 1968 at approximately the 1967 level. Major improvements in facilities and equipment were initiated. Construction of an addition to the biomedical building at the PRNC site in Rio Piedras will double the space available for training, education, and research programs in the medical, biological, and agricultural sciences. At the PRNC site in Mayagüez, work was started on upgrading the 1 Mw. research reactor to a steady-state level of 2 Mw. with pulsing capabilities of 2,000 Mw.

During the year, 213 students from 23 countries and the United States were at the center.

Chapter 15

BIOMEDICAL AND PHYSICAL RESEARCH

Nuclear research more and more requires an interdisciplinary approach. This fact is most apparent in the physical and life science research projects underway in the AEC's national laboratories and in university and college laboratories where nuclear research is conducted. Results of the more basic scientific investigations are presented in this chapter along with brief descriptions of new facilities being provided for fundamental research. The "highlights" noted are taken from somewhat more detailed summaries appearing in the AEC's report on "Fundamental Nuclear Energy Research—1968." [1]

BIOLOGY AND MEDICINE

The biomedical research program of the AEC has three major objectives. The most urgent requirement is a better understanding of the principles and mechanics of radiation interaction with living systems. Given the basic facts, there is the need, next, for scientific guidance of radiation control that can be extended and refined. Finally, important, and sometimes vital, problems in the life sciences are being resolved through the use of radiation and byproduct (radioisotope) materials.

The AEC's biological, medical, and environmental sciences research is conducted under more than 640 contracts. These contracts support work at nearly 250 universities, commercial research organizations, and other Federal agencies. Most of the work is done under AEC contract at such major installations as the Argonne National Laboratory and Argonne Cancer Research Hospital, Chicago, Ill.; the Brookhaven National Laboratory, Long Island, N.Y.; Lawrence Radiation Laboratory, at both Berkeley and Livermore, Calif.; Los Alamos Scientific

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $4.25.

Laboratory, Los Alamos, N. Mex.; Oak Ridge National Laboratory, Oak Ridge Associated Universities, and the University of Tennessee-AEC Agricultural Research Laboratory, all in Tennessee; and the Pacific Northwest Laboratory at the AEC's Hanford Works near Richland, Wash.

RECENT ADVANCEMENTS

The AEC's biomedical research is unusual in that it must first supply elementary information about the life processes themselves before more advanced radiation effects studies are begun. Thus, AEC-sponsored studies are providing new information that may not be immediately associated with nuclear energy. A number of highlights of the more recent and interesting findings are included here. These, and other findings, are described more fully in part III of the supplemental report, "Fundamental Nuclear Energy Research—1968." That portion of the report includes three feature sections covering AEC-sponsored immunology studies, terrestrial ecology research, and recent advances in AEC-supported biomedical engineering.[2]

Immunology

- Studies done on animals to determine the effect of radiation exposure rates on antibody-forming tissues suggest that, to support bone marrow grafts in patients with blood diseases, radiation should be given at an extremely fast rate.
- Research has shown that antibody formation depends on an interaction among three different cell systems—scavenger cells which engulf foreign material invaders; the thymus (an endocrine gland); and the bone marrow.

Terrestrial Ecology

- It has been clearly shown that exposure levels from naturally high background radiation can be of potential genetic and ecological importance to highly radiosensitive plant populations.
- Studies in a variety of environments (desert to rain forest) indicate that recovery from the effects of ionizing radiation tends to follow normal and predictable successional patterns already observed in areas recovering from fire, logging, or mining of topsoil.

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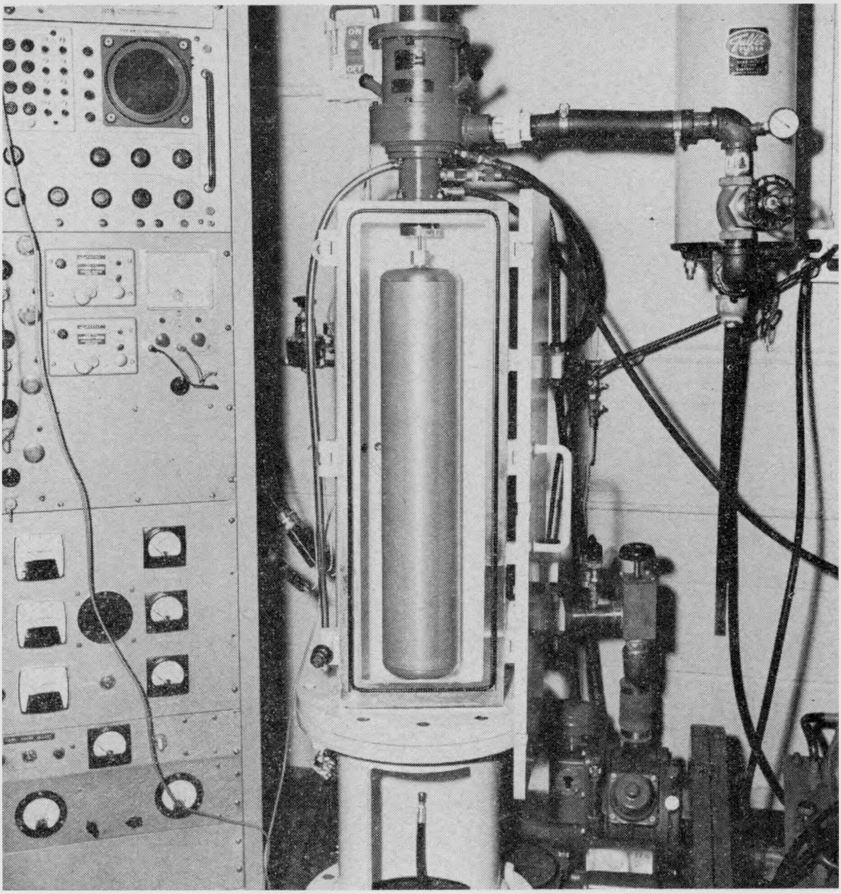
[2] Available in reprint form from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $0.15 a copy for each section.



For the Production of High Purity Vaccines a high-speed, large volume liquid centrifuge (shown with door open) was designed and developed at the Oak Ridge Gaseous Diffusion Plant in support of work being conducted by the Oak Ridge National Laboratory under a joint Molecular Anatomy Program sponsored by the AEC and the National Institutes of Health. Purification of vaccines using this new system results in the removal of up to 80 percent of extraneous matter, such as foreign protein, which causes side effects and limits dosage. The development of highly purified vaccines is also expected to permit the inclusion of multiple vaccines in one inoculation. The AEC has made the plans and specifications for the centrifuge available to interested parties to assist in the development of commercial sources of such centrifuge systems. The action is consistent with the AEC's policy to disseminate unclassified scientific and technical information originating under its various research, development, and production programs. There is increasing interest in the centrifuge system by the pharmaceutical industry for the production of large volumes of highly purified vaccines.

Environmental Radiation Studies

• The distribution of stable elements in the environment, for those elements which have potentially hazardous radionuclides, is proving a useful way to determine the likely pathways of radioactive isotope dispersion.

Biomedical Engineering

• A number of interesting achievements in the field of "bioengineering" include innovations such as (*a*) the use of the computer to analyze images; (*b*) electronic analysis and separation of cells and viruses for purified vaccines; (*c*) improved counting systems; (*d*) analysis of intact living systems; and (*e*) several advances in using the familiar light microscope.

Cancer Research

• A new cancer therapy facility for low exposure rates of whole-body irradiation of patients with chronic leukemia has been developed and is in use. The design permits an unusual degree of relative comfort and mobility for the patient while he is under treatment.

• A new scanner for detection of cancer is capable of simultaneously recording radioactivity emitted at different levels of the body making possible the detection of lesions at unknown depths. The new scanner produces pictures which provide sharp resolution at planes above and below the normal focal plane.

• Recent work with bone cancer suggests that radiation may induce these cancers by inactivating a biological inhibitor of a cancer-producing virus. In mice, radiation-induced bone cancers contain virus-like particles resembling a virus which has been shown to cause bone cancer in this species. There now is evidence that human bone cancer does contain virus-like particles that can produce bone cancer in hamsters.

Somatic Effects of Radiation

• Experiments show that diminished oxygen in a space vehicle, caused by hull leak or micrometeorite penetration, would still stimulate the formation of new red blood cells despite radiation damage to blood-forming tissues—a compensatory reaction characteristic of mammals.

Toxicity of Radioelements

• The form in which plutonium enters the body determines the pattern of deposition in tissues, the extent of damage, and the effectiveness of decontamination of tissues by chelation therapy. The biological behavior of insoluble particulates is largely determined by scavenger cells which engulf and transport the particles.

• Personal dosimeters for measurement of radioactivity in air breathed by uranium miners are being developed by studies in universities and industry; ingenuity has been exercised to miniaturize the personal dosimeters to increase their practicality for specific uses.

Radiation Genetics

• Information obtained from studies of biological organisms flown on the Biosatellite II mission suggests that the weightless state, or some other feature of space flight, affects genetic response to radiation in rapidly dividing and metabolically active cells; no such effect is found in cells which do not undergo division or are inactive metabolically.

Molecular and Cellular Level Studies

• The first enzyme to be discovered that was able to repair radiation damage to DNA, key cellular materials which carry the information cells need to reproduce themselves, was the photoreactivating enzyme which was first identified in bacteria and yeast. It splits ultraviolet-induced pyrimidine dinucleotides in DNA. It has now been found to occur in shell fish, insects, fishes, amphibians, and birds, but not in mammals. The question remains as to what additional function the enzyme may perform.

• The chemical products formed by radiation may be toxic to cells, but before the biological activity of these products can be studied, their structure must first be determined. Such a determination has been made in the case of crystalline choline chloride—a chemical compound that is decomposed by inonizing radiation to a greater extent than any other known compound.

Radiation Health Physics

• High-speed digital computers now calculate the dose from gamma rays emitted by radionuclides deposited in the human body. The new techniques are valuable to the physician who administers radioisotopes for diagnosis.

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Atmospheric Radioactivity and Fallout

- A computer program has been developed which can predict the dispersion of sulfur dioxide from urban fossil-fueled industrial plants.
- Diminishing levels of radionuclides in precipitation, food, soil, and man, and in the biosphere in general, have come about from the declining atmospheric burden and reduced fallout rate. Cesium-137 is declining rapidly; strontium-90 and carbon-14 much less rapidly because of the longer physical and biological half-lives of these radionuclides. Although environmental fallout levels continue downward, the rate of reduction in the United States was less in 1968 because of fresh debris injected into the stratosphere by foreign nuclear detonations.
- Work on environmental lead clearly demonstrates that the evaluation of the possible toxicity of lead from motor fuels must include studies on numerous foods and plants. Research has shown that the uptake of lead from soil and air differs depending on the particular plants used in the study.

A Civil Defense Studies Technician at the UT–AEC Agricultural Laboratory in Oak Ridge, Tenn., examines soybean plants which have been irradiated as part of a research study being conducted by the laboratory for the Office of Civil Defense. Under the program, damage to the growing plant which might result from fallout is being investigated in crops of soybeans, corn, and rice. The plants are grown in containers so they might be easily transported to the radiation source for the appropriate amount of radiation at the desired time during their growth period. The laboratory, established in 1948 for the purpose of studying the effects of radiation on plants and animals, is operated for the AEC by the University of Tennessee.

NUCLEAR ENERGY CIVIL EFFECTS

The AEC continues to accumulate scientific information on the effects of ionizing radiations on man and his environment. The nuclear energy civil effects program maintains a capability for aerial radiological monitoring and carries out studies at the Nevada Test Site and at the Oak Ridge National Laboratory (ORNL) in cooperation with the Department of Defense.

A series of radiation measurements made by ORNL obtained data related to the prompt radiation from the Hiroshima and Nagasaki bombs. Mockups of the bomb casings of World War II design were used for the measurement of radiation leakage. A californium-252 radioactive source was positioned within the bomb casings to simulate—without an explosion—the prompt radiation emitted by a nuclear bomb. (Californium-252 decays by spontaneous fission producing fission neutrons at an appreciable rate.) The radiation leakage through the unfragmented casings is important because it represents the source of most of the initial ionizing radiations which reach the ground from a nuclear weapon air burst.

Laboratory instruments were used to measure the radiation leakage at various locations outside the bomb cases. In this manner, useful data were obtained on the quantity and energy of the early neutrons and gamma rays which were produced in each of the 1945 explosions. These data are likely to provide human dosimetry equations useful to the Atomic Bomb Casualty Commission in studies of the long-term biological effects of radiation in man.

Bikini Resettlement Seen

A little more than 10 years after the last nuclear weapons test took place at Bikini Atoll, the Bikini people have been given reassurance that they will be able to return to their home island after it has been prepared for habitation.

The Bikinians were removed before the first nuclear weapons tests began in 1946 in the mid-Pacific Ocean area (Marshall Islands). Nuclear tests spanned the period 1946 through 1958. The past decade has brought a remarkable recovery to the islands as noted by AEC-sponsored biological survey teams in 1964 and in 1967.

A radiological survey of the Bikini Atoll and a study by a scientific group led to the Presidential decision, this year, that the island could be made habitable for the Bikini people.[3]

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[3] See AEC public announcement of Aug. 12, 1968 (L–191), available from the Division of Public Information, U.S. AEC, Washington, D.C. 20545.

NEW BIOMEDICAL RESEARCH FACILITIES

Construction was completed on two new Government-owned biomedical research facilities during the year.

Animal Laboratories—Brookhaven National Laboratory

The Brookhaven medical research program attacks diseases of man through laboratory and clinical investigations. The latter takes place in the hospital section of the BNL Medical Research Center. In both types of investigations, animals play an important part. For example, exploratory use of accelerator or reactor beams, or extracorporeal irradiation of blood are undertaken with the primary objective of application to a human patient. Extensive studies with animals must be completed before the techniques for successful application to human beings are developed.

Additions have been made to the animal quarantine building and to the main Medical Research Center at Brookhaven. In the latter case, a one-story animal laboratory structure with basement has been attached directly to the present building. The gross area is 18,400 feet and consists of rooms for the care, treatment, and observation of animals, and service rooms for maintaining the necessary sanitary conditions.

Biomedical and Animal Laboratories at Livermore

A laboratory and office building of 43,000 square feet and an animal laboratory of 8,000 square feet will be completed by mid-1969 at the AEC's biomedical research project at the Lawrence Radiation Laboratory, Livermore.

The added space will provide laboratory, office, and animal space for the biomedical research program designed to advance human knowledge of the biological implications of radiation, especially as they affect man. Accordingly, the program is studying the incorporation of radionuclides in food chains leading to man.

The accomplishment of the mission of the research program means that the behavior of many chemical elements, and radioactive forms of these elements, must be studied with respect to intake, metabolism, and excretion. A part of this mission deals with man and another, especially with respect to food chain considerations with animals.

Although considerable research has been accomplished on fission products in experimental animals, the envisioned Livermore program covers a broader scope. For example, tritium and induced activities (from Plowshare program detonations) in a variety of materials present in the explosive devices, in the environment, or in diagnostic packages could create biologically significant radioactivities not associated with fission products.

PHYSICAL RESEARCH

The AEC physical research program is chiefly concerned with basic research which seeks to discover new scientific knowledge and to further the understanding of existing knowledge. Research is carried out in high, medium, and low energy physics, mathematics and computers, chemistry, metallurgy and materials, and in controlled thermonuclear phenomena. The greatest portion of this program is conducted at AEC-owned research facilities.

A smaller but also important part of the basic physical research effort is conducted at offsite locations supported by AEC through contracts. There are 567 such contracts for specified work conducted at 157 institutions which include universities, colleges, and other nonprofit research institutions, commercial research organizations, and other Federal agencies.

RECENT ADVANCEMENTS

The physical research section of the "Fundamental Nuclear Energy Research—1968" presents a broad view of the work resulting from this research program. Following are some of the significant achievements covered in the 1968 research report.

Metallurgy and Materials

- Recrystallization occurs in alpha-plutonium concurrent with deformation. The quality, besides having scientific interest, permits deformation without cracking.
- Single crystals of alpha-plutonium have been grown at high pressure and will permit studies of this important nuclear material.
- A number of radiation-produced defects in platinum metal have been identified enabling extension of the information to a large group of metals where the thermal recovery from damage is similar.
- Thermal conductivity measurements at temperatures approaching absolute zero have been used to detect irradiation-produced defects in potassium chloride crystals. As a result, a better understanding of

the basic nature of solids and a new tool for nondestructive testing of material was achieved.

- A very sensitive bolometer has been developed and may be used to detect cosmic radiation with a better understanding of the origin of the universe as a possible result.

Chemistry

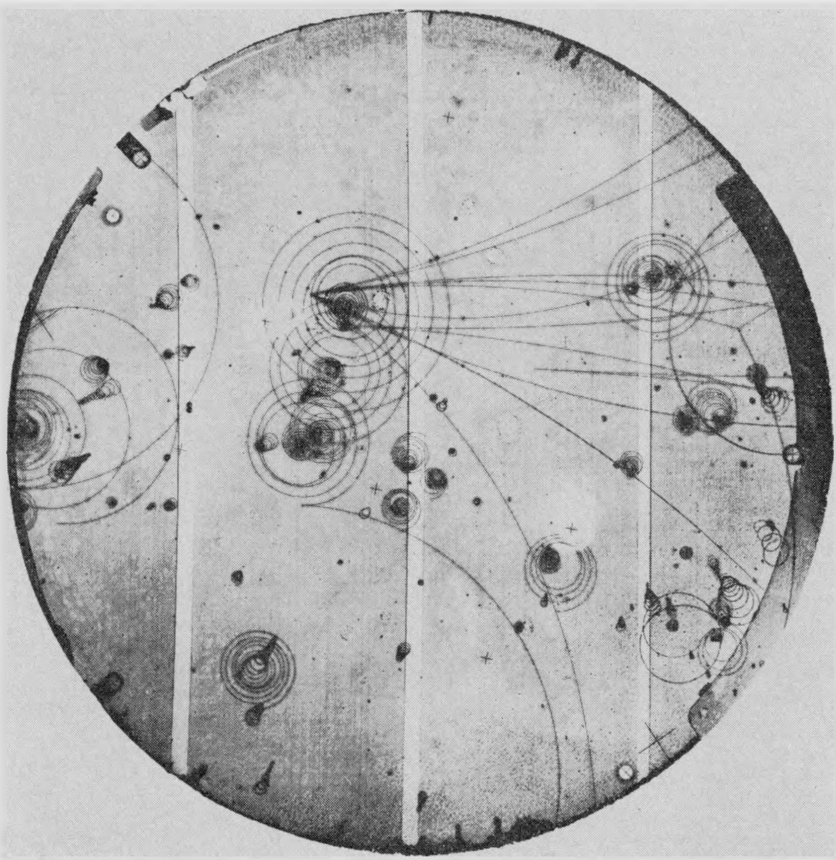
- The isotope curium-242 was produced and fashioned into sources for the highly successful alpha-scattering experiments in the Surveyor lunar soft-landing missions. The results indicate that the moon's surface, at least at the landing sites, is much like terrestrial basalt.
- The discovery of mendelevium-258, the heaviest isotope observed by man, enhances prospects of finding heavier and as yet undiscovered elements. The unexpectedly long half-life of this isotope opens the door to chemical studies usually not possible with the shorter lived isotopes from this region of the Periodic Table.
- The prediction, made over 20 years ago, that the last member of the actinide series (element 103, lawrencium) would be predominantly tripositive in the oxidation state and that the next-to-last member of the series (element 102, nobelium) would, in addition, have a dipositive oxidation state, has been confirmed.
- Chemical bonds have been seen in a new and unprecedentedly direct way by combining X-ray and neutron diffraction measurements. Densities of bonding and nonbonding electrons have been mapped for the molecule known as s-triazine.
- The natural occurrence of plutonium in the early solar system has been inferred and is proposed as evidence that chemical elements heavier than uranium are being synthesized in supernova within our galaxy.

High Energy Physics

- Results of a recent experiment at the Stanford Linear Accelerator Center show that reassessment of the photo-production theory may be necessary. While it had been predicted, on the basis of theory, that more secondary particles would emanate off axis from the line of collision of high energy photons with target nucleons than would emanate straight ahead, the opposite has been found to be true.
- In a newly developed slow extracted beam system at the Alternating Gradient Synchroton (AGS), the primary proton beam is extracted and directed toward the experimental area. There the desired secondary particles are produced through collisions with targets ex-

ternal to the accelerator and closer to the detection apparatus which results in improved particle intensities, particularly of short lived secondaries.

- The Cambridge Electron Accelerator has successfully achieved multiple pulse injection and beam storage and has successfully passed the accelerated electron beam through the beam bypass. The bypass carries the beam out of the main accelerator ring, through a special focussing section where stored beams may collide efficiently, and back



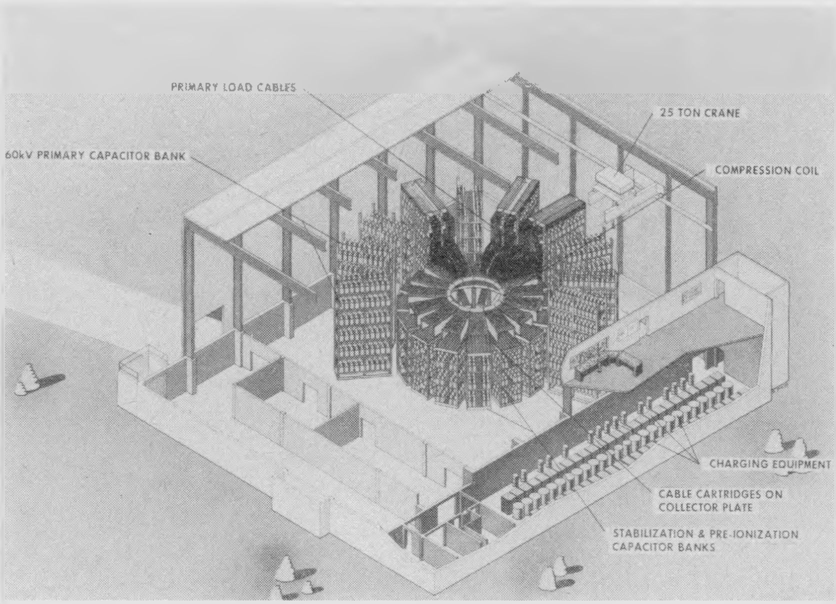
Operation of the Stanford Linear Accelerator (SLAC) has already provided valuable new scientific information. Photo, taken in a SLAC bubble chamber, shows the tracks of nine particles produced when a high-speed photon struck the nucleus of a hydrogen atom in the chamber. The high-energy photon was produced by allowing SLAC's 2-mile electron beam to strike a target, releasing the photon. Such experiments have shown the need for reassessing old theories concerning atomic particles. Designed as a 20-Bev. machine, the 21-Bev. accelerator also exceeded its design intensity of 50 milliamperes on the weekend of December 7.

into the main ring. The bypass has been added to the accelerator so that colliding-beam experiments can be done using the synchrotron as the storage ring.

- An automatic airlock control system is now in operation at the AGS which permits the transfer of targets from the atmosphere to the inside of the accelerator vacuum system under remote control thereby reducing the opportunity for human radiation exposure.

Low and Medium Energy Physics

- Measurements of the nuclear mass and the excited states of neutron-rich light nuclei strengthen the possible existence of yet undiscovered nuclei containing large numbers of neutrons. Lithium-9,



Ground Was Broken for Scyllac, one of the world's largest and most promising controlled thermonuclear research experiments, on November 22, 1968, at Los Alamos Scientific Laboratory. The major components of the Scyllac facility are shown *above.* Briefly, the charging equipment (*lower right*) provides energy which is stored in the main capacitor bank. A suitably prepared gas is admitted into the vacuum vessel located within the compression coil, and this gas is preionized by an auxiliary discharge. Subsequently, the main bank is discharged through the coil creating a high magnetic field which in turn compresses and contains the energetic plasma which is produced. This plasma—in which the particle pressure is comparable to the magnetic field pressure—will produce a large number of fusion reactions but the total released energy will be less than would be required for a practical powerplant.

nitrogen-18, and fluorine-22 were studied because, among the lighter elements, these isotopes contain the largest number of neutrons.

- New evidence supports the theory that many of our heavy elements were formed slowly in stellar interiors and that the remainder, including uranium and thorium, were created shortly before the solar system was formed in a supernova or cataclysmic event.

Controlled Thermonuclear Research

- An essentially turbulent-free plasma has been obtained in toroidal multipole devices. These devices provide the strong magnetic well responsible for reducing turbulence and thereby improving plasma confinement.

Mathematics and Computer Research

- New mathematical error bounds have been obtained for accurate approximations to the solutions of linear and nonlinear boundary value problems providing a new tool for use in relation to diffusion theory of neutron reactors and similar problems.
- Use of computers to make numerical calculations needed in designing accelerator magnets speeds up the process and, with the introduction of an on-line graphic display system, much of the design work can be completed in just one session at the computer console.

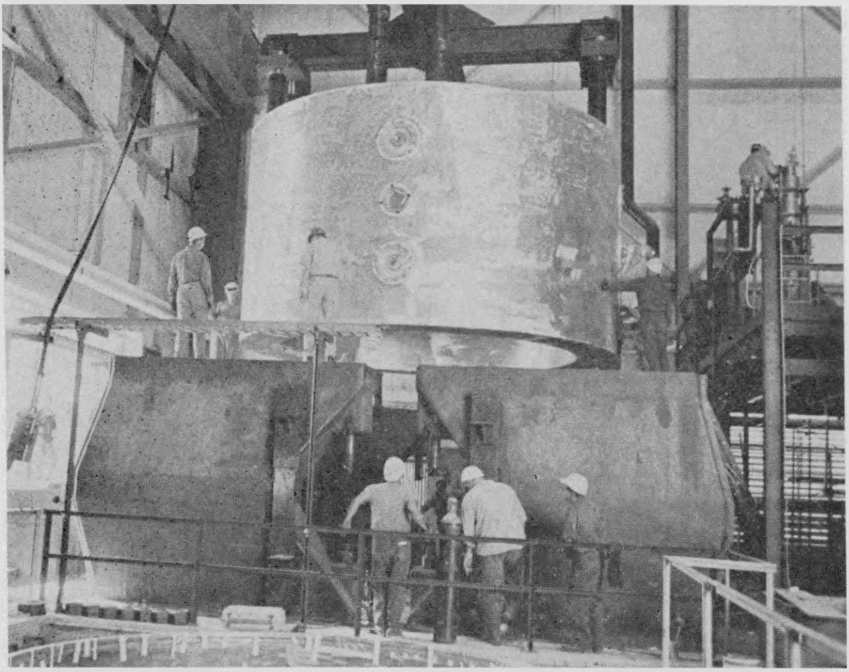
PHYSICAL RESEARCH FACILITIES

The quest for and understanding of basic physical laws often is accompanied by a need for unique and sophisticated research facilities. This does not preclude conversion and updating of present research facilities when technically and economically feasible.

AGS Conversion

The 33 Bev. Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory, Upton, N.Y., is undergoing a major conversion to increase its beam intensity from the present level of about one trillion protons a second to approximately 10 trillion protons a second. This is to be accomplished by replacing the 50 Mev. injector with a new linear accelerator injector having an energy of 200 Mev. and by augmenting the power supply of the AGS magnet to the extent that the cycling rate can be doubled. Additional shielding will be provided and certain machine components will be relocated or modified to protect against radiation damage and higher levels of induced radioactivity which occurs when the accelerator beam is on. Experimental facilities will be expanded for use of the increased beam intensity.

The modification will permit experiments heretofore not possible because of the large amounts of machine time required. In addition, it will provide the statistics needed to sharpen the resolution and interpretation of certain experiments and will support more simultaneous experiments.



The World's Largest Superconducting Magnet is shown being lowered into its massive steel frame at Argonne National Laboratory. The 110-ton magnet will be used with the laboratory's new 12-foot hydrogen bubble chamber, now under construction. When energized, this unique magnet will generate a magnetic field of 18,000 gauss (36,000 times the magnetic field of the earth). A liquid helium refrigerant will be used to cool the magnet to within a few degrees of absolute zero. At this temperature, the niobium-titanium alloy used in the magnet coils will become superconducting, offering no electrical resistance. A comparable magnet of conventional design would require 10 million watts. When completed, the bubble chamber will be used to study new particles generated by Argonne's Zero Gradient Synchroton (ZGS). The superconducting magnet passed a major milestone during a December 17 test when the twin coils attained a field of 18.5 kilogauss.

At present, construction is being performed while the AGS continues to operate. However, two machine shutdown times will occur later. The conversion is scheduled for completion in late 1971 at an estimated construction cost of $47.8 million.

National Accelerator Laboratory

On December 1, a groundbreaking ceremony was held for the National Accelerator Laboratory which will be constructed on a 6,800-acre site in DuPage and Kane Counties, Ill. (about 30 miles west of Chicago) donated by the State of Illinois. The principal scientific instrument of the laboratory will be a proton synchrotron of 200 Bev. energy designed for a beam intensity of 50 trillion protons a pulse or 15 trillion protons a second.

The most prominent part of the accelerator will be the main magnet ring which will have a diameter of 1¼ miles. A unique feature of the accelerator design is the capability to raise the peak proton energy to more than 400 Bev.—perhaps as much as 500 Bev.—without seriously interrupting the research program in progress.

Funds in an amount of $14,574,000 have been made available for design and initiation of construction in fiscal 1969. The total estimated construction cost of the project is $250 million.

Engineering design is proceeding by the laboratory staff and DUSAF,[4] the architect-engineer-construction manager. The initial construction contracts were awarded in late 1968.

Meson Physics Facility

In mid-February 1968, ground was broken at the Los Alamos Scientific Laboratory for construction of a half-mile-long proton linear accelerator to be known as the Los Alamos Meson Physics Facility.[5] When completed in 1972, it will deliver high intensity beams of 800 Mev. protons which, in turn, will provide secondary beams of pi mesons and other particles for experimental use in the life and physical sciences.

Electron Ring Accelerator (ERA)

A novel particle accelerator concept, now being developed in the Soviet Union, is being studied at the Lawrence Radiation Laboratory,

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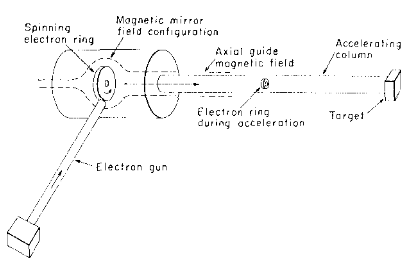
[4] DUSAF is a joint venture firm composed of the following: Daniel Mann, Johnson, and Mendenhall, Los Angeles; the Office of Max O. Urbahn, New York; Seelye, Stevenson, Value and Knecht, Inc., New York; and George A. Fuller Co., New York.

[5] See pp. 259–260, "Annual Report to Congress for 1967."

Berkeley. The concept calls for the acceleration of intense, doughnut-shaped rings of electrons carrying protons or other positively charged particles. The electrons are the particles being accelerated, and the positively-charged particles go along for the ride, being constrained to the ring by the intense electric field of the electrons. The object is to obtain energetic positively-charged particles by this indirect means. This method may hold promise of providing a variety of accelerators that are considerably smaller and cheaper than those using conventional accelerator technology.

Theoretically, a relatively modest increase in the energy of the electrons should yield a very large increase in the energy of the accompanying positively-charged particles. This result derives from the large difference in mass between the electron and the positively-charged particles. The proton, for example, is typically 40 times more massive than the transverse relativistic mass of the electron (that is, the effective mass of the electrons rotating in the ring). As a consequence, a proton hitching a ride in an accelerated electron ring would gain energy at about 40 times the rate of the electrons.

Lawrence Radiation Laboratory's Livermore facility has a unique electron linear accelerator, used as an injector for the Astron experiments in controlled thermonuclear research. This accelerator, which produces high intensity bursts of electrons (300 amperes) at an energy of 3.4 Mev., was felt to be uniquely suited to a prompt test of the ERA principles.



The Concept of the Electron Ring Accelerator (ERA), now under study at the Lawrence Radiation Laboratory, Berkeley, is shown in the drawing. Short bursts of electrons are fired into the ERA cylinder by the electron gun. The magnetic field surrounding the cylinder is so shaped that the electrons form a rapidly spinning ring of about 25 centimeters (10 inches) in radius, which is held together by the self-induced magnetic field of the spinning electrons themselves. Increasing the magnetic field strength compresses the ring to a radius of five centimeters. When a neutral gas, such as hydrogen, is injected into the region of the electron ring, it is ionized, producing protons which are captured by the ring. Both the electron ring and bound protons are accelerated down the column toward the target by means of radiofrequency cavities or by means of a pulsed-line method of acceleration. After acceleration, the electrons can be separated from the protons if desired, so that only protons hit the target. (*Note:* Normally there would not be two rings in the accelerator at once; the compressed ring shown in the column represents the larger ring at a later time.)

The Berkeley laboratory constructed a model of the first stage of an electron ring accelerator and successfully tested it in October, using the Astron Accelerator. This experiment showed that intense rings of electrons can be stably formed and magnetically compressed to a size and density suitable for accelerator applications.

The Berkeley laboratory is now preparing an experiment to test the next crucial step, namely the initial acceleration of an intense electron ring loaded with protons. This step is crucial because at this point the ring could easily become unstable or lose its load of protons. Beyond this step, there are several alternative methods of acceleration, both magnetic and electric, which must be evaluated experimentally.

In summary, at this point the ERA principle still looks promising, but further model work will be essential to determine its feasibility.

Chapter 16

INDUSTRIAL PARTICIPATION ASPECTS

NUCLEAR INDUSTRY GROWTH

The AEC has a direct and vigorous interest in increasing industrial participation in nuclear energy activities. The Atomic Energy Act of 1946, and the subsequent 1954 revision of the Act, established the policy that, among other important objectives, the development and use of atomic energy should be directed toward strengthening the industrial economy. The original Act also permitted the operation of Government-owned plants under contract so as to gain the full advantage of the skill and experience of American industry in the conduct of the AEC programs.

Over the years since 1946, both the AEC and Congress, through the Joint Committee on Atomic Energy, have taken many steps to widen industrial opportunities in the nuclear field, and to encourage participation by industry in nuclear activities.[1] These steps have resulted in a spirit of cooperation between Government and industry that has contributed much to this country's position of world leadership in the development and use of nuclear energy.

Resurgence in Growth

Although the nuclear industry had a long period of sustained growth beginning with commercial applications of radioisotopes in the 1940's, the tremendous surge to nuclear power for electric generation, which began in 1965, has led to a vigorous infusion of atomic energy activities into the economic pattern of the country.[2]

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[1] See pp. 40–41, "Annual Report to Congress for 1961."

[2] For a complete report on the atomic energy industry, see *"The Nuclear Industry—1968,"* 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 $2.00.

Indications of the extent to which this will be increasingly felt in the years ahead are the following:

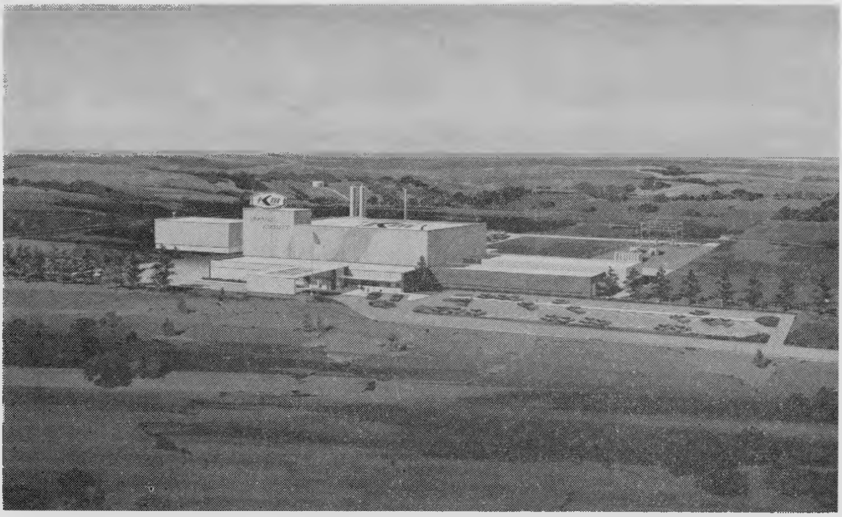
- Orders for a selected group of nuclear products, as reported by the Census Bureau for 1967, exceeded $1½ billion, or more than twice the total reported for 1966 and more than six times the 1965 total.
- At the end of 1968, there were 91 nuclear powerplants operating, under construction, or on order with a total estimated cost of more than $10 billion.
- New manufacturing facilities to supply components or services for nuclear powerplants were under construction at more than 15 locations at an estimated cost of more than $250 million.
- Expenditures for nuclear powerplants and for fuel for the plants are estimated at $40 billion over the 13-year period 1968–80.

COMPETITION IN THE NUCLEAR INDUSTRY

As nuclear energy has moved more and more into the industrial sector of the economy,[3] the AEC has been increasingly concerned with the degree of competition in the emerging nuclear industry.

Questions concerning the future of competition are based on four salient facts:

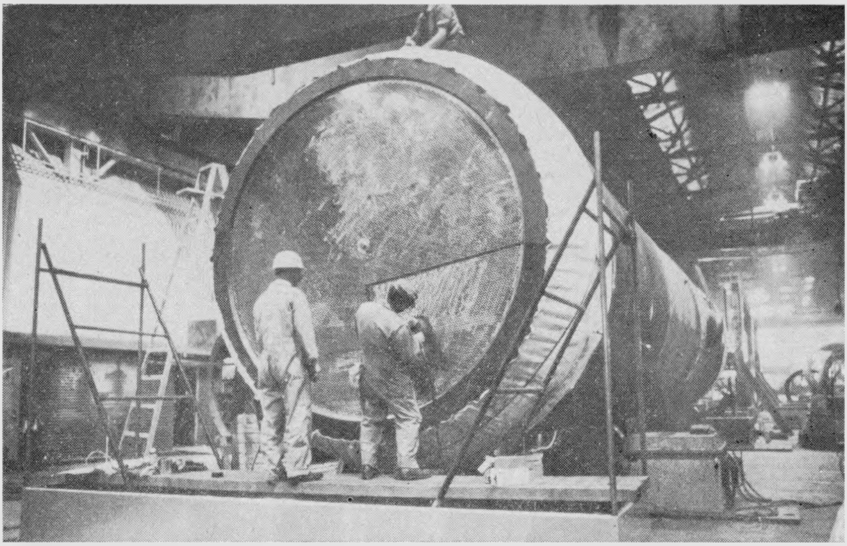
[3] For a discussion of the extent of industrial participation, see "The Nuclear Industry—1968 and Beyond" a talk by Chairman Seaborg given in New York City on Oct. 30, 1968, available from Division of Public Information, U.S. AEC, Washington, D.C. 20545.

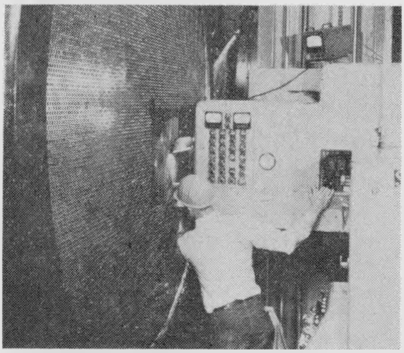


Architectural Drawing of Kerr-McGee's Uranium Hexafluoride plant which will be constructed in Sequoyah County in eastern Oklahoma. Scheduled for completion early in 1970, the plant will be able to process between 5,000 and 10,000 tons of uranium per year for use as power reactor fuel.

(*1*) An economic nuclear power industry developed earlier and grew more rapidly than at first believed possible.
(*2*) The trend to large central station nuclear powerplants is now well underway.
(*3*) Legislation permitting private ownership of nuclear fuels opened the way for enterprise to participate more fully in nuclear power and related businesses.
(*4*) Private participation in most ancillary nuclear industrial services has grown so that it embraces virtually all activities.

In considering the relationship between these facts and healthy competition, and in its relations with the industry, the AEC's actions can have a profound effect on the industry. Also, under the Atomic Energy Act, the AEC is expected to carry out its activities in a manner





The Face of the Steam Generator for Duke Power's Oconee Nuclear Station is shown being polished (*above*) during fabrication at the Barberton, Ohio, Works of Babcock & Wilcox Co. Photo at *left* shows deep hole drilling of a tube sheet for the Oconee steam generators. This first of three 839-Mwe. pressurized water reactor units is scheduled to go into operation in 1970; two additional units are scheduled for operation in 1971 and 1972, respectively, at the Oconee plant site in the northwestern corner of South Carolina.

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consistent with the antitrust laws as administered by the Department of Justice.

Economic Policy Study

These considerations led to discussions with the Justice Department and to agreement on the need for a jointly sponsored thorough economic study of the nuclear supply industry. Arthur D. Little, Inc., Cambridge, Mass., was selected to make the study. This study was the first of its type in that it was designed to develop economic and structural information on an industry still in its formative stages. The study was designed to provide guidance to responsible Government officials so that it might be possible for them to influence the competitive growth of the nuclear supply industry at its onset, rather than rely on remedial measures after undersirable trends have developed.

The study culminated in a report, completed in late 1968, which provides detailed information on each segment of the nuclear power supply industry and analyzes its competitive aspects. It also includes a presentation of Government policy objectives for the industry and discusses possible Government policy approaches for meeting the objectives.[4]

COOPERATION WITH INDUSTRY

As a part of its continuing program of cooperation with the private nuclear industry, the AEC has found it essential to maintain continued communications with industry associations and with state and local governments.

Industry Associations

Frequent meetings between AEC and leaders of industry associations with interests in the nuclear field have provided for a free and informal exchange of views on matters of mutual interest. In 1968, the Commissioners met on this basis with the Board of Directors of the Atomic Industrial Forum, the atomic energy policy committee of the Edison Electric Institute, the American Public Power Association, and the Board of the Association of Nuclear Instrument Manufacturers.

Other associations also provide important channels of communication between AEC and industry. These include the Chamber of

[4] *Competition in the Nuclear Power Supply Industry*, a report by Arthur D. Little, Inc., to the U.S. AEC and the U.S. Department of Justice, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $4.50.

Commerce of the United States, the National Security Industrial Association, the Manufacturing Chemists Association, and the American Iron and Steel Institute.

Cooperation Between Laboratories

The research and development advisory committee of the National Security Industrial Association has established an AEC Panel on Government-Industry Laboratories. The primary goal of the panel is to foster a greater understanding and cooperation between the industrial research community and the AEC's Oak Ridge, Brookhaven, and Argonne National Laboratories. At year's end, the panel was discussing this area with the Commission's staff.

TRIP Steels

A 1-day symposium was held at AEC headquarters on October 21, 1968, to discuss with representatives of the steel and metals fabricating industries the possible applications of TRIP (transformation-induced plasticity) steels.[5] This series of steels, developed at the University of California under AEC contract, have unusual high-strength, high-ductility characteristics. The objectives of the meeting were to assure that the latest information on TRIP steels was made known to potentially interested commercial concerns and to determine industry's interest in fostering early development of commercial applications. Eighty-two persons attended representing 30 industrial concerns, seven Government agencies, three trade associations, three trade publications, two universities and one foreign government.

Work Experience Program

During the past 10 years, 365 industry representatives have participated in the AEC's work experience program. The participants have come from 180 organizations and have spent some 285,000 hours in the program.

The work experience program is an AEC project to provide an opportunity for industrial employees to learn more about specialized work being carried out at AEC facilities throughout the country. While the participants and their companies profit from the special training, the AEC programs in turn are enriched by the knowledge and experience of the industry representatives.

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[5] See pp. 87–88, "Fundamental Nuclear Energy Research—1967."

Regional Support Activities

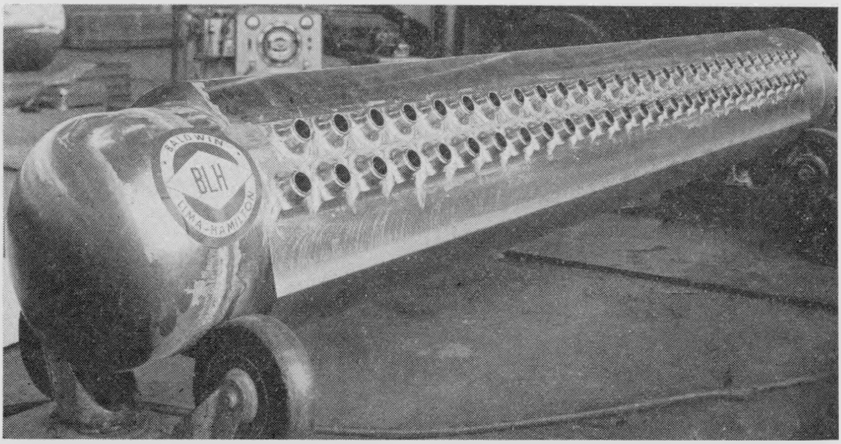
Interstate compacts provide a means of coordinating regional efforts in the nuclear field permitting activities on a regional scale that could be difficult for an individual State to support.

Southern Interstate Nuclear Board

The Southern Interstate Nuclear Board (SINB) [6] was established to help foster the sound development of nuclear energy in the South, to help the States meet the growing influence of nuclear energy in new fields as well as in traditional areas of State responsibility, and to develop a balance of authority and responsibility between the States and the Federal establishment. It serves as an important communications link between the AEC and regional leaders.

Among the more important activities of SINB is the sponsoring of seminars which provide excellent channels of communication among industry, State and Federal Government and others. Two of these were held in 1968. One in May in Oklahoma City was on "Nuclear Fuel: Exploration to Power Reactors," with 435 participants from 37 States

[6] Composed of member States of the Southern Governors' Conference: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Affiliation has been offered to Puerto Rico and tne Virgin Islands.



A Crevice-Free Radiographable Tube-Tube Sheet joint was designed for use in reactors using liquid sodium as a coolant by Baldwin-Lima-Hamilton, Philadelphia, Pa. This type of joint was used in the fabrication of the intermediate heat exchangers and heat dumps for the SEFOR experimental reactor at Fayetteville, Ark. Photo shows a completed manifold prior to attachment of "heat dump" heat exchanger tubes, using the crevice-free radiographable tube joint.

and 12 foreign countries. Another, in September in Louisville, Ky., was on "Science, Technology, and State Government," and was aimed at exploring the advancement and use of science and technology at the State and local levels. More than 225 participants attended from 24 States and the District of Columbia.

Other Regional Compacts

The western Governors,[7] the midwestern Governors,[8] and the New England Governors[9] have all considered interstate nuclear compacts in conjunction with their respective conferences. These compacts would be somewhat comparable to the one establishing the SINB and are visualized as fostering commercial and industrial progress in each region by maximizing the benefits of nuclear and related scientific and technical resources and skills through cooperative efforts of the associated States.

The most advanced of these compacts is that fostered by the western Governors. It is expected that enough States (five) will have enacted enabling legislation in 1969 to bring the compact into effect and that approval of the compact by Congress will be concurrent with legislation by the States.

A midwest compact was endorsed by the midwestern Governors conference in 1966 and a final draft of enabling legislation has been prepared for consideration by the individual States.

The New England Governors have asked their utilities commissioners to review the desirability of a New England nuclear compact and make recommendations to the Governors. AEC representatives have met twice with the Commissioners and further steps toward a compact seem likely in 1969.

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[7] Representing: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, Guam, and American Samoa.

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

[9] Representing: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

Chapter 17

ADMINISTRATIVE AND MANAGEMENT MATTERS

EMPLOYMENT DATA

The impact on the nation's economy of increased participation by private enterprise in the nuclear energy field is reflected in the annual survey of employment which the Bureau of Labor Statistics conducts for the AEC. The mid-1968 survey showed:

(*1*) More than 510 industrial and educational establishments with a total of 141,700 persons working in the atomic energy field in 1968, compared to 136,500 in 1967.

(*2*) Employment in 65 Government-owned establishments of 99,000 persons, which reflects no change from the previous year.

(*3*) Employment among 446 industrial establishments totaled 41,395, a 13.5 percent increase over the mid-1967 total.

(*4*) Of the 35,700 scientists and engineers reported in the survey, 67 percent were engaged in research and development work.

LABOR MANAGEMENT RELATIONS

About 28,000, or some 29 percent, of the employees in the Government-owned facilities are represented by labor unions.

Union Affiliation	*Approximate Representation*	*Percent*
Metal Trades Council (AFL–CIO)	9, 621	34
International Association of Machinists (AFL–CIO)	4, 975	18
Oil, Chemical & Atomic Workers Intl. Union (AFL–CIO)	3, 350	12
Office Employees International Union (AFL–CIO)	1, 875	7
Miscellaneous guards unions (independents)	1, 415	5
Miscellaneous unions (excluding guards)	6, 862	24
Total	28, 098	10

The Atomic Energy Labor-Management Relations Panel intervened in the following labor-management disputes at Government-owned facilities during 1968:

(*1*) A wage reopener dispute between Reynolds Electrical & Engineering Co., Inc., and the Carpenters Union at the Nevada Test Site.
(*2*) An initial contract dispute between Union Carbide Corp., at Oak Ridge, Tenn., and the Service Employees Union representing employees at the Oak Ridge National Laboratory Biology Division.
(*3*) A contract renewal dispute between Brookhaven National Laboratory, and the International Brotherhood of Electrical Workers representing maintenance employees. This was not a formal intervention—instead, the Panel provided mediation assistance.

Work Stoppages

Time lost in work stoppages by AEC contractor employees from January through December 1968, amounted to 101,771 man-hours, most of which were on construction jobs. This represents 0.04 percent of scheduled working time. In calendar year 1967, a total of 183,695 man-hours was lost.

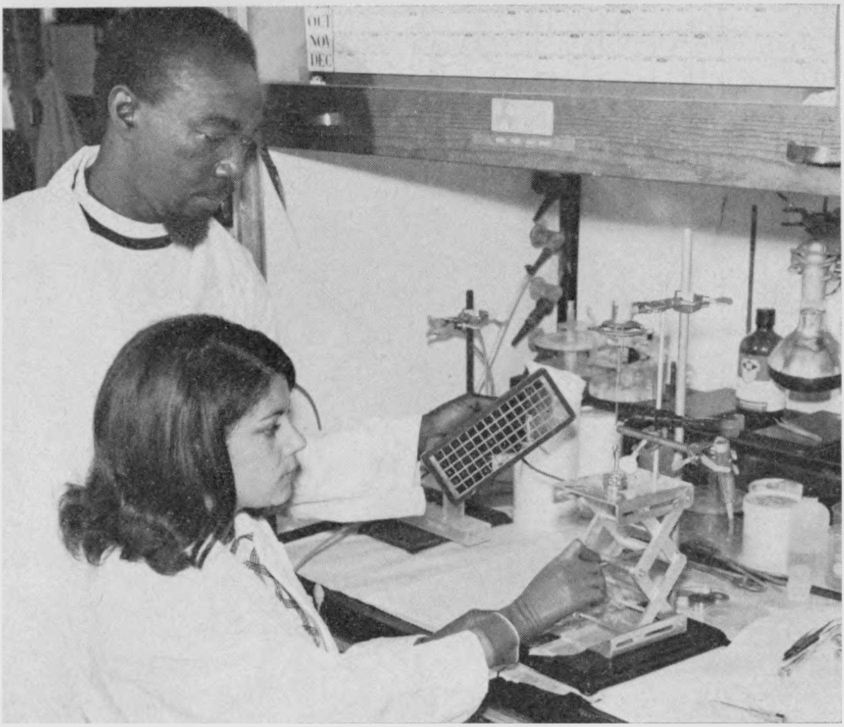
EQUAL EMPLOYMENT AND TRAINING

Youth Opportunity Campaign

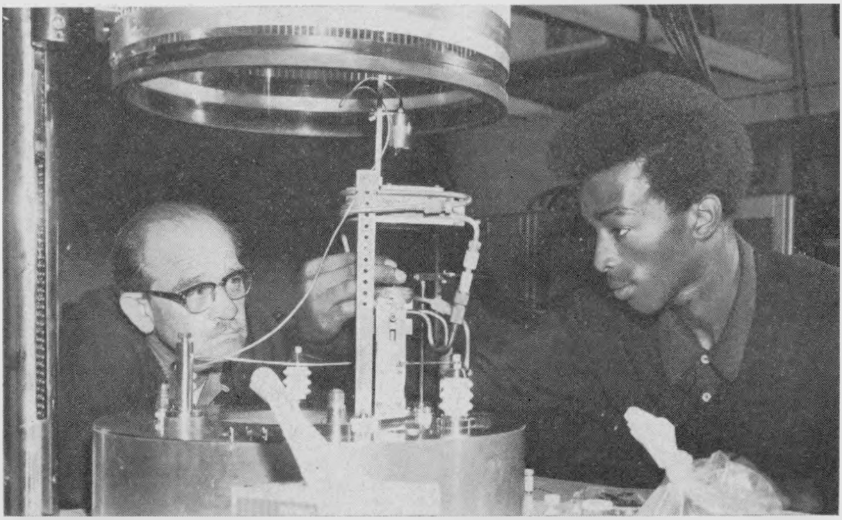
The youth opportunity campaign provides work opportunities and training experience for young men and women, ages 16 to 21, during the summer months. AEC contractors have participated each summer since the program was inaugurated throughout the United States in 1965.

During the summer of 1968, contractors operating AEC laboratories and plants employed 1,016 young people under the program. Approximately 65 percent of the youths were from minority groups and 45 percent were Negro. College students made up 36 percent of the employees, 48 percent were high school graduates, 13 percent were high school students, and about 2 percent were high school dropouts. More than 63 percent were males, and 54 percent of all employees were in the 16 to 18 age group, and 46 percent were 19 years and over.

The 1,016 employees worked in the following job categories: engineering or laboratory aides, 234; plant clericals, 111; office clericals,



Sixty-Five Young People from Oakland and Berkeley were employed for the 3 summer months under the Youth Opportunity Campaign (YOC) at the Lawrence Radiation Laboratory (LRL), Berkeley, operated for the AEC by the University of California. Photo *above* shows a YOC participant helping to set up a vaporizer to make calcium targets for "atom-smashing" experiments with the 88-inch cyclotron. In photo *below*, a LRL staff chemist is assisted by a YOC participant in an experiment to advance the technology of targets of heavy elements.



378; maintenance helpers, 47; and all others, 246. As part of the program, four AEC laboratories developed summer science plans in which selected high school students with particular interests in science were assigned to work directly with laboratory scientists. At Ames Laboratory, Brookhaven National Laboratory, Los Alamos Scientific Laboratory, and the Stanford Linear Accelerator Center, these young people assisted scientists in such activities as assembly and disassembly of nonenergized electronic systems and processing and plotting of experimental data.

Equal Employment Activities by Contractors

Contractors at AEC-owned facilities reexamined their affirmative action programs and intensified efforts to hire, train, and upgrade minority group persons. During the year ending September 30, 1968, these contractors hired 18,205 employees, including 2,086 Negroes and 1,523 other minorities. On September 30, 1968, Negroes represented 4.0 percent of total employment and other minorities represented 4.1 percent compared with September 1967 rates of 3.3 percent and 3.9 percent.

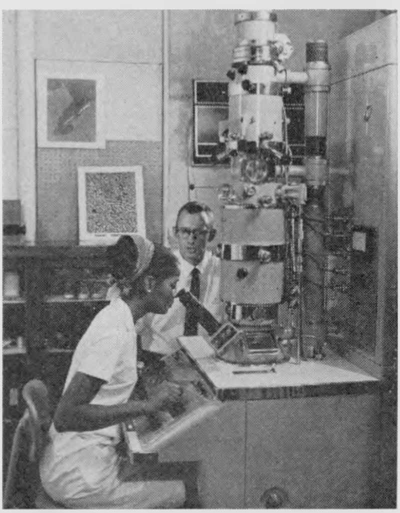
Several AEC laboratories began hiring and training hard-core unemployed and other disadvantaged persons. Supportive services, including transportation and housing assistance, were arranged for inner-city residents in some instances. Vestibule and in-plant programs of basic education and skills training were conducted by many contractors to qualify unskilled applicants and employees for clerical, technician, machine operator, and other jobs.

Chicago and Richland contractors opened employment offices in minority residential areas. Elsewhere, recruitment contracts were established with Indian reservations and Alaskan native groups, and with Negro and Spanish-American organizations. Contractors also recruited at predominantly Negro colleges to fill professional and management trainee positions.

In connection with major AEC construction programs at Oak Ridge, Tenn.; Rocky Flats, Colo.; and Batavia, Ill., preapprentice recruitment and preparation programs were established, with the assistance of the Department of Labor and the building trades unions. These programs are bringing minority youths into skilled construction crafts in those localities. Fifty-seven minority youths were trained as heavy equipment operators at the Argonne National Laboratory site by the Operating Engineers Union under a contract with the Department of Labor, and are now working in the construction industry.

AEC Equal Employment

The AEC's offices strengthened their plans for equal employment opportunity. AEC policy statements during the year reemphasized the need for continuing positive efforts in equality of employment oppor-



Updating a Scale Model of the Bendix-AEC facility in Kansas City, Mo., was the assignment of three (*above*) of the 67 participants in the firm's Youth Opportunity Campaign (YOC) program. In photo at *left*, a YOC employee learns to operate an electron microscope under the supervision of a metallurgical technician at the AEC's Fernald Feed Material plant operated by National Lead Co. of Ohio. At the AEC's Portsmouth, Ohio, Gaseous Diffusion Plant, the Goodyear Atomic Corp. employed 23 students for YOC and special summer training programs in 1968. Work assignments were designed to be compatible with their academic backgrounds and interest.

tunity. Training sessions were conducted for AEC supervisors with the participation of top management. Plans have been made for additional sessions.

Summer vacation provided an opportunity to attract and employ members of minority groups who are college students with a view toward their selection for permanent positions following graduation. The advice of minority group personnel was sought and obtained in preparation of plans for more effective recruitment campaigns, employee participation activities, and in the employment and training of youth.

Experimental Training

An experimental project at Oak Ridge, Tenn., under the Manpower Development and Training Act, demonstrated that disadvantaged people can be successfully trained in industrial environments for skilled jobs in modern industry. This project was carried out in 1966–1968 at the Oak Ridge Y–12 facility by three AEC contractors under interagency agreements among AEC, the Department of Labor (DOL), and the Office of Education. Overall project direction and supportive services were provided by Oak Ridge Associated Universities. The staff of Union Carbide Corp., conducted the skilled training programs, and the University of Tennessee provided guidance and counseling services and assisted in the determination and testing of experimental objectives. Training was provided in welding, machining, electronics, physical testing, drafting, and glass blowing, and 525 persons were graduated.

Following the conclusion of this experimental and demonstration project, a regular Manpower Development and Training Act program was authorized for training approximately 300 individuals. The first group of 190 persons, of whom 42.1 percent are from minority groups, started this training program on October 7, 1968. Training is offered in the same subjects as in the experimental and demonstration program, except that mechanics replaces glassblowing. Training will average about 9 months per trainee and most of the graduates are expected to be employed by Union Carbide. The cost of this 1-year program is supported jointly by AEC and DOL.

DIVERSIFICATION AND TRANSFER

With the cooperation of the AEC and its contractors, the diversification of the economy of the Richland, Wash., area continues. The AEC's diversification program began in 1964 when the AEC announced plans to operate Hanford by multiple contractors and adopted policies to assist the Richland area in establishing an economic base less dependent on AEC activities. In selecting new contractors, consideration was given to commercial activities which prospective contractors proposed for the area. By mid-1968, total employment at the Hanford Works plus employment in contractor's private diversification activities was about the same as the total site employment before the AEC cutback in production as a result of the Presidential announcement of January 8, 1964.

New Diversification Activities

Atlantic Richfield Hanford Co. (ARHCO), the AEC contractor operating the chemical processing facilities at the Hanford plant, started construction of one of its diversification facilities, a resort and convention facility at Richland on July 15, 1968. The company started work earlier in the year on another diversification project—a cattle feedlot—located nearby in the Walla Walla port district.

On January 18, 1968, Battelle-Northwest, the Battelle Memorial Institute's subdivision which operates the AEC's Pacific Northwest Laboratory, announced plans to construct a 90,000-square-foot, $3.8 million addition to its own laboratory complex at Richland. Construction was begun on the second increment in Battelle's projected $20 million facility.

A zirconium tubing fabrication plant, a United Nuclear diversification project undertaken with Sandvik Special Metals Corp., was dedicated on August 9, 1968. The new plant is located at Finley, Wash. The United Nuclear Corp. and McDonnell Douglas Corp. are the owners of Douglas United Nuclear (DUN), Inc., the AEC contractor operating the Hanford production reactors. The McDonnell Douglas Corp. diversification activity is the Donald W. Douglas Laboratories, dedicated early in 1967 and located at Richland.

Center for Graduate Study Completed

The Center for Graduate Study at Richland was completed in September 1968. Funds for this $1.5 million educational facility came from the Hanford Works diversification contractors, the State of Washington, local municipal (Tri-Cities) [1] organizations, and the Federal Government by a grant from the U.S. Office of Education. The center provides graduate education and academic research opportuni-

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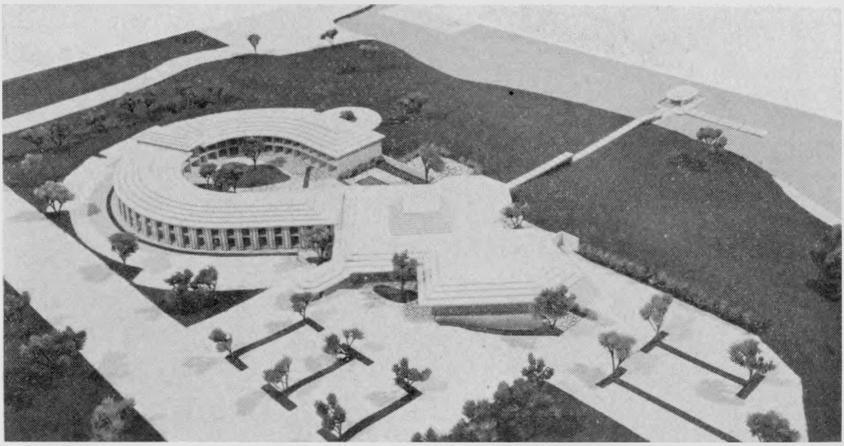
[1] Richland-Pasco-Kennewick, Wash.

ties for personnel associated with the Hanford site. The University of Washington (Seattle), Washington State University (Pullman), and Oregon State University (Corvallis), participate in the center's programs (see also "Graduate Centers" item in Chapter 14—"Nuclear Education and Training").



Construction of Hanford House is underway in Richland, Wash. The $3-million resort hotel and convention center, a major segment of Atlantic Richfield Hanford Co.'s $6-million diversification program proposed for the Richland area in the firm's successful bid to operate the chemical-processing facilities at the nearby Hanford complex. The two-story circular portion of the building will contain 150 guest rooms; banquet space for 500; and restaurant, dining room, and cocktail lounges overlooking the Columbia River. Construction is expected to be completed by August 1969. The economy of the "Tri-cities" (Richland, Pasco, Kennewick) area, which has been heavily dependent on the AEC's Hanford plant, took another big step toward diversification early in 1968 with completion of the Sandvik Special Metals Corp. zirconium tube plant near Kennewick. The new firm is half-owned by United Nuclear Corp., which also is one of the two owners of Douglas United Nuclear, Inc., the AEC's reactor operator at Hanford. The plant produces zirconium tubing for use in power-reactor fuel elements.

Farming Experiment on Hanford Site

The use of two sections of undeveloped land in the Hanford Works site has been offered by AEC to the State of Washington for a proposed 4-year farming experiment using warmed cooling water from the "N" reactor for irrigation. The experiment would seek to demonstrate agricultural benefits of using warm water for irrigation while at the same time reducing thermal pollution.

DISPOSAL OF FACILITIES

Hanford Redox Plant

On October 9, 1968, the AEC invited expressions of interest from industry in the Redox facility at Hanford, a chemical processing complex built for recovery of plutonium and uranium from irradiated fuel elements. The facility, which was shut down in June 1967, is capable of being modified for the processing of spent fuel from the growing number of nuclear powerplants. If substantially modified, the plant would be capable of handling up to 700 metric tons a year of spent fuel from power reactors. Six industrial concerns—Allied Chemical, Atlantic Richfield, Gulf General Atomic, National Lead, S. M. Stoller Associates, and Tomorrow's Markets—responded to the AEC invitation. Formal expressions of interest will be received by the Commission in early 1969.

Los Alamos Community Disposal

Progress continued during 1968 toward ending AEC ownership and management of the community at Los Alamos, N. Mex., as authorized by legislation approved September 28, 1962.

Sale of Real Property

The sale of real property at Los Alamos, N. Mex., has been virtually completed. Apartment sales are well underway, following passage of amended disposal legislation in late 1967, which permitted sales to private individuals and others as well as cooperatives. All commercial property offered for sale and all church and nonprofit properties have been sold.

Community Operation

The AEC continued to make annual assistance payments to the county, hospital, and schools. The AEC is responsible for all unsold

Government property remaining in the community, and for the utilities and other facilities in the technical areas and in the other portions of the Los Alamos County (including fire protection) that are not subject to disposal.

RADIATION EXPOSURE RECORDS

The AEC had published for public comment in late 1967 a proposed rule change (to 10 CFR Part 20)[2] which would expand its present licensee record keeping requirements to include the reporting of certain identification and radiation exposure information to a central repository. Based upon the comments received on the proposed rule change and the recommendations of the Commission's Labor-Management Advisory Committee, the AEC, on November 4, 1968, adopted a radiation exposure recordkeeping system for implementation with its contractors exempt from licensing and the following types of AEC licensees: (*a*) operators of nuclear power reactors and testing facilities; (*b*) commercial processors of specified quantities of byproduct material; (*c*) reactor fuel processors and reprocessors; and (*d*) industrial radiographers. Information to be incorporated in the system and furnished to a central repository includes the following:

(*1*) *Annual Reports of Exposure Information.* Annual reports are to be submitted setting forth (*a*) total number of individuals for whom personnel monitoring was required, and (*b*) individual exposure information only for those persons who received an annual external dose in excess of prescribed quarterly limits (*e.g.*, 1.25 rems whole body exposure.)

(*2*) *Exposure Information on Termination of Employment.* A report of the cumulative occupational radiation exposure incurred by monitored transient workers or former employees during their tenure of employment or work assignment in a licensee or contractor facility to be furnished the central repository within 30 days after termination of the individual's work assignment or employment.

(*3*) *Reports of Exposure in Excess of Limits.* Reports of both external and internal exposures in excess of applicable limits will be incorporated in the central repository by AEC as received under existing regulations (reported at time overexposure is incurred).

On December 19, the AEC published in the *Federal Register* an amendment to 10 CFR Part 20 implementing the above reporting requirements to be effective 60 days from the date of publication. Be-

[2] See pp. 291–292, "Annual Report to Congress for 1967" and the "*Federal Register*," vol. 32, No. 222, p. 15762, November 16, 1967.

cause of the previous interest expressed in the development of a records and reports system for radiation workers, comments on the proposed rule change have been invited.

Pilot Recordkeeping Program

The AEC is ascertaining the interest of a few selected States in participating in a pilot recordkeeping program for radiation workers including the reporting of summary identification and exposure information to a central repository. It is believed that such a program will provide the AEC, participating States, and employers of radiation workers, greater flexibility to experiment with the detail of data, forms, and procedures in perfecting a recordkeeping system.

Uranium Miners

Meetings have been held with the major uranium producing States (Arizona, Colorado, New Mexico, Utah, and Wyoming) to determine their interest in the establishment of a pilot recordkeeping system. The results of these meetings indicate that the system initially should be limited to the reporting of uranium miner exposure information to a central repository. The establishment of such a system would provide, among other things, a mechanism for tracing the exposures of uranium miners employed in more than one State. (See also item in Chapter 7—"Operational and Public Safety.")

Workmen's Compensation Standards

Legislation (18 bills) was introduced in seven States in 1968 covering, in whole or in part, one or more of the AEC's recommended workmen's compensation standards. Six bills were enacted into law; two on radiation injury coverage (Ariz. and R.I.), one on adequate time limit (Ariz.), one on vocational rehabilitation (Md.), one reduced numerical exemption from five to three (Kans.), and one extended medical benefit limitation from $2,500 to $25,000 (La.).

Radiation Cases

The AEC is currently in the process of conducting a study of workmen's compensation cases involving injury and disease alleged to have been caused by occupational exposure to ionizing radiation. This work

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when completed will be incorporated into a report and published. It is hoped that the information presented would be helpful to workmen's compensation administrators, State legislators, and others.

CONTRACTING POLICY

A new "performance fee" arrangement has been negotiated with the General Electric Co. for operations at the AEC's Pinellas Plant (near St. Petersburg, Fla.). This concept is designed to overcome certain problems heretofore experienced with the cost-plus-incentive fee arrangement under this operating contract. A unique feature of this concept provides that the AEC will unilaterally determine the amount of the performance fee award within agreed-upon limits. Such determinations are based upon established criteria selected to serve as guideposts for subsequent evaluations of the quality and effectiveness of the contractor's performance. If successful, it is hoped that this concept could be applied to other similar contracts.

Guide for Submission of R&D Proposals

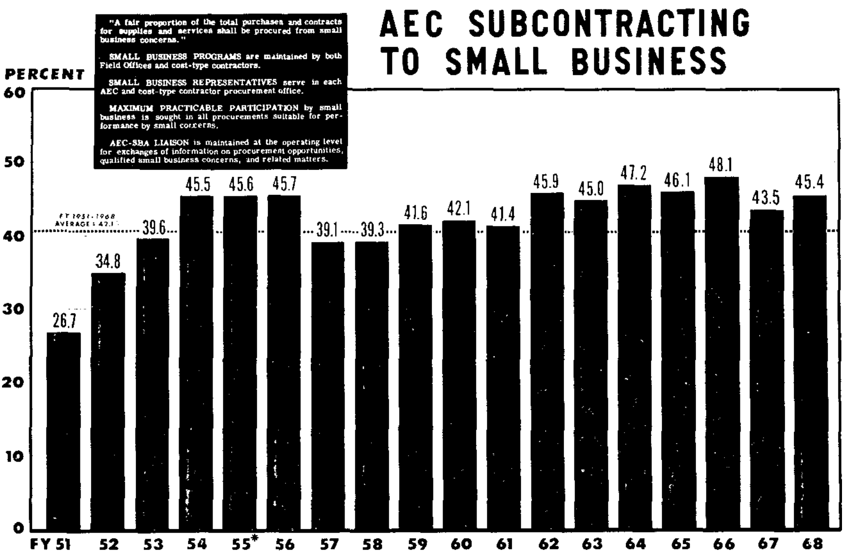
The AEC published a new guide for submission of research and development proposals by commercial firms as a companion to its existing guide for educational institutions. This new publication provides convenient guidance on the desired content of unsolicited proposals from other than educational institutions. The pocket-size guide entitled "Guide for Submission of Research and Development Proposals by Individuals, Commercial Firms and Not-for-Profit Organizations Other Than Educational Institutions," is available at major AEC field offices and at AEC headquarters.

AEC Contract for National Accelerator Laboratory

The AEC signed a contract with the Universities Research Association (URA) covering design and construction of the planned 200 billion electron volt (Bev.) accelerator laboratory to be located near Batavia, Ill. URA was principally engaged in design and related research and development activities under the contract during 1968. The 200-Bev. accelerator, the principal facility planned for the proposed laboratory, will be the biggest instrument ever built for basic scientific research.

AEC Subcontracting to Small Business

During fiscal 1968, for the sixth time in 7 years, AEC prime contractors awarded over 45 percent of the subcontracts to small business concerns: $350 million of $770 million or 45 percent. AEC assistance to small business has averaged 42 percent of subcontract awards during the period 1951 through 1968.



	FY 51	52	53	54	55*	56	57	58	59	60	61	62	63	64	65	66	67	68
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
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

* Does not include three Kiewit Co. Subcontracts at Portsmouth, Ohio which are in the nature of prime contracts

Board of Contract Appeals

The Board of Contract Appeals is the authorized representative of the Commission to hear, consider and decide appeals arising under AEC prime contracts and certain subcontracts. The board's rules are pubished in 10 CFR Part 3.

The board (see Appendix 2 for membership) sits in three member panels except in accelerated proceedings. In accelerated proceedings, either the chairman or vice chairman sits alone.

During the 4-year period of its existence, the Board of Contract Appeals has docketed 57 appeals and 1 special proceeding—an average caseload of about 15 cases per year.

Disposition by Agreement

The board policy of actively encouraging and participating with the parties in disposing of disputes by agreement continues as an important means of resolving contract disputes. As a result of this policy, in those cases in which disposition by agreement is appropriate, stronger efforts are being exerted by contracting officers to dispose of disputes by agreement without the necessity of appeal proceedings.

The use of pretrial conference techniques is primarily responsible for the quick disposition by agreement of appealed disputes. One of the primary purposes of the conference, as stated in the board's rules (10 CFR Part 3), is "to bring the parties together informally to consider the possibility of disposing of the appeal by agreement."

Accelerated Procedure and Small Business

An accelerated procedure that provides for the consideration and disposition of appeals without regard to their normal position on the docket continues to aid the expeditious resolution of those appeals in which the procedure is used. The accelerated procedure may be used when the amount in dispute does not exceed $10,000 or for other good causes shown.

To avoid hardships which administrative proceedings may cause small businesses, the board, in 1968 as in prior years, made every effort to accommodate small businesses in promptly granting the accelerated procedure and in holding conferences and hearings at or near the location of the small business.

Average Pendency of Appeals

The board has been able to dispose of both accelerated and nonaccelerated appeals without unnecessary delay. The average period of pendency for accelerated proceedings is 80 days and for nonaccelerated proceedings is 146 days..

APPENDIX 1

ORGANIZATION AND PRINCIPAL STAFF OF U.S. ATOMIC ENERGY COMMISSION

COMMISSIONERS

Atomic Energy Commission	GLENN T. SEABORG, *Chairman* JULIUS H. RUBIN, *Special Assistant* JAMES T. RAMEY JOHN C. RYAN, *Special Assistant* GERALD F. TAPE JACK ROSEN, *Special Assistant* WILFRID E. JOHNSON GERARD F. HELFRICH, *Technical Assistant* FRANCESCO COSTAGLIOLA JOHN A. GRIFFIN, *Special Assistant*
Secretary to the Commission	W. B. MCCOOL
Controller	JOHN P. ABBADESSA
General Counsel	JOSEPH F. HENNESSEY
Director, Division of Inspection	CURTIS A. NELSON
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
Assistant to the General Manager	HARRY S. TRAYNOR
Assistant to the General Manager for Program Analysis	ROGER W. A. LEGASSIE
Deputy General Manager	EDWARD J. BLOCH
Assistant General Manager	HOWARD C. BROWN, Jr.
Director, Division of Industrial Participation	ERNEST B. TREMMEL
Director, Division of Intelligence	C. H. REICHARDT
Director, Division of Public Information	JOHN A. HARRIS
Director, Office of Congressional Relations	ROBERT D. O'NEILL
Special Assistant for Disarmament	ALLAN M. LABOWITZ
Assistant General Manager for Operations	JOHN A. ERLEWINE
Assistant for Economic and Community Affairs	GEORGE J. KETO
Assistant for Workmen's Compensation and Radiation Records	CHARLES F. EASON
Director, Division of Construction	JOHN A. DERRY
Director, Division of Contracts	JOSEPH L. SMITH
Director, Division of Labor Relations	H. T. HERRICK
Director, Division of Operational Safety	MARTIN B. BILES
Assistant General Manager for Research and Development	SPOFFORD G. ENGLISH
Director, Division of Biology and Medicine	JOHN R. TOTTER
Director, Division of Isotopes Development	E. EUGENE FOWLER
Director, Division of Nuclear Education and Training	RUSSELL S. POOR
Director, Division of Peaceful Nuclear Explosives	JOHN S. KELLY
Director, Division of Research	PAUL W. MCDANIEL

Assistant General Manager for Plans and Production	GEORGE F. QUINN
Director, Division of Operations Analysis and Forecasting	PAUL C. FINE
Director, Division of Plans and Reports	WILLIAM H. SLATON
Director, Division of Production	F. P. BARANOWSKI
Director, Division of Raw Materials	RAFFORD L. FAULKNER
Assistant General Manager for Reactors	GEORGE M. KAVANAGH
Director, Division of Naval Reactors	VAdm. H. G. RICKOVER, USN
Director, Division of Reactor Development and Technology	MILTON SHAW
Director, Division of Space Nuclear Systems	MILTON KLEIN
Assistant General Manager for International Activities	MYRON B. KRATZER
Director, Division of International Affairs	MYRON B. KRATZER
Assistant General Manager for Administration	JOHN V. VINCIGUERRA
Director, Division of Classification	C. L. MARSHALL
Director, Division of Headquarters Services	EDWARD H. GLADE
Director, Division of Personnel	DONALD E. BOSTOCK
Director, Division of Security	WILLIAM T. RILEY
Director, Division of Technical Information	EDWARD J. BRUNENKANT
Assistant General Manager for Military Application	Maj. Gen. EDWARD B. GILLER, USAF
Controller, Office of the Controller	JOHN P. ABBADESSA
General Counsel, Office of the General Counsel	JOSEPH F. HENNESSEY
Director, Division of Inspection	CURTIS A. NELSON
Director, Office of Safeguards and Materials Management	DELMAR L. CROWSON

Managers of Field Offices

Albuquerque (N. Mex.) Operations Office	HAROLD C. DONNELLY
Amarillo (Tex.) Area	(Vacant)
Burlington (Iowa) Area	E. W. GILES
Dayton (Miamisburg, Ohio) Area	WILLIS B. CREAMER
Kansas City (Mo.) Area	HENRY A. NOWAK
Los Alamos (N. Mex.) Area	H. JACK BLACKWELL
Pinellas (Fla.) Area	WALTER C. YOUNGS, Jr.
Rocky Flats (Colo.) Area	SETH R. WOODRUFF, Jr.
Sandia (N. Mex.) Area	LADDIE W. OTOSKI
Brookhaven (Upton, N.Y.) Office	E. L. VAN HORN
Chicago (Ill.) Operations Office	KENNETH A. DUNBAR
200 Bev. Accelerator Facility	KENNEDY C. BROOKS
Grant Junction (Colo.) Office	ALLAN E. JONES
Idaho (Idaho Falls) Operations Office	WILLIAM L. GINKEL
Nevada (Las Vegas) Operations Office	ROBERT MILLER [1]
Honolulu (Hawaii) Area	WILLIAM A. BONNET
New York (N.Y.) Operations Office	WESLEY M. JOHNSON
Health and Safety Laboratory (New York City)	JOHN H. HARLEY
Oak Ridge (Tenn.) Operations Office	S. R. SAPIRIE
Cincinnati (Ohio) Area	CLARENCE L. KARL
New Brunswick (N.J.) Area	C. J. RODDEN
Paducah (Ky.) Area	BERNARD N. STILLER
Portsmouth (Ohio) Area	ROY V. ANDERSON
Puerto Rico (San Juan) Area	J. PERRY MORGAN
Pittsburgh (Pa.) Naval Reactors Office	LAWTON D. GEIGER
Richland (Wash.) Operations Office	DONALD G. WILLIAMS
San Francisco (Calif.) Operations Office	ELLISON C. SHUTE
Canoga Park (Calif.) Contract Representative Office	A. P. POLLMAN
Palo Alto (Calif.) Area	HOWARD C. HOOPER
Savannah River (Aiken, S.C.) Operations Office	NATHANIEL STETSON
Schenectady (N.Y.) Naval Reactors Office	STANLEY W. NITZMAN

[1] Effective Jan. 1, 1969, James E. Reeves, retired.

AEC Scientific Representatives Abroad

Bombay, India	Harold F. McDuffie, Jr.
Brussels, Belgium	Dixon B. Hoyle, *Senior Representative*
Buenos Aires, Argentina	Robert H. Goeckermann
Chalk River, Ontario, Canada	Robert W. Ramsey Jr.
London, England	William L. R. Rice
Paris, France	Joseph J. DiNunno
Rio de Janeiro, Brazil	Robert H. Wilcox
Tokyo, Japan	Whittie J. McCool

LICENSING AND REGULATORY FUNCTIONS

Director of Regulation	Harold L. Price
Deputy Director	Clifford K. Beck
Assistant Director for Reactors	M. M. Mann
Assistant Director for Administration	C. L. Henderson
Assistant Director for Special Projects	Richard L. Doan
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	Forrest Western
Director, Division of Materials Licensing	John A. McBride
Director, Division of State and Licensee Relations	Eber R. Price
Director, Division of Nuclear Materials Safeguards	Russell P. Wischow

Directors of Compliance Regional Offices

Region I (New York)	Robert W. Kirkman
Region II (Atlanta)	John G. Davis
Region III (Chicago)	Boyce H. Grier
Region IV (Denver)	Donald I. Walker
Region V (San Francisco)	Richard W. Smith

Directors of Nuclear Materials Safeguards District Offices

District I (New York)	Walter G. Martin
District II (Oak Ridge)	William B. Kenna
District III (Berkeley)	Vincent N. Rizzolo

APPENDIX 2

MEMBERSHIP OF COMMITTEES, ETC., DURING 1968

STATUTORY COMMITTEES AND BOARDS

Joint Committee on Atomic Energy—90th Congress (Second Session)

The committee 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 Commisson 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 1968, the committee was composed of:

Senator JOHN O. PASTORE (Rhode Island), *Chairman* [1]
Representative CHET HOLIFIELD (California), *Vice Chairman*
Senator RICHARD B. RUSSELL (Georgia)
Senator CLINTON P. ANDERSON (New Mexico)
Senator ALBERT GORE (Tennessee)
Senator HENRY M. JACKSON (Washington)
Senator BOURKE B. HICKENLOOPER (Iowa)
Senator GEORGE D. AIKEN (Vermont)
Senator WALLACE F. BENNETT (Utah)
Senator CARL T. CURTIS (Nebraska)
Representative MELVIN PRICE (Illinois)
Representative WAYNE N. ASPINALL (Colorado)
Representative THOMAS G. MORRIS (New Mexico)
Representative JOHN YOUNG (Texas)
Representative CRAIG HOSMER (California)
Representative WILLIAM H. BATES (Massachusetts)
Representative JOHN B. ANDERSON (Illinois)
Representative WILLIAM M. MCCULLOCH (Ohio)
EDWARD J. BAUSER,[2] *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

[1] Under Sec. 203 of the Atomic Energy Act of 1954, as amended, the Chairmanship alternates between the Senate and the House with each Congress; it is expected that Representative Holifield will be the Chairman and Senator Pastore the Vice Chairman during the 91st Congress.

[2] Successor to John T. Conway who resigned effective Oct. 31, 1968.

all such matters before the Commission. The Department of Defense, through the Committee shall keep the Commission fully and currently informed on all matters within the Department of Defense which the Commission deems to relate to the development or application of atomic energy. The Department of Defense through the Committee shall have the authority to make written recommendations to the Commission from time to time on matters relating to military applications of atomic energy as the Department of Defense may deem appropriate. If the Department of Defense at any time concludes that any request, action, proposed action, or failure to act on the part of the Commission is adverse to the responsibilities of the Department of Defense, the Secretary of Defense shall refer the matter to the President whose decision shall be final."

Hon. CARL WALSKE, *Chairman*
Maj. Gen. OTTO J. GLASSER, United States Air Force
RAdm. ROBERT E. RIERA, United States Navy
Maj. Gen. ROBERT E. COFFIN, United States Army
Brig. Gen. JAMES A. HEBBELER, United States Army
Brig. Gen. CHARLES W. LENFEST, United States Air Force
Capt. JAMES G. WHITEAKER, United States Navy

General Advisory Committee

This 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.

Dr. NORMAN F. RAMSEY, *Temporary Chairman*; Professor of Physics, Harvard University, Cambridge, Mass.

Dr. JOHN C. BUGHER, retired (formerly Director, Puerto Rico Nuclear Center, San Juan, P.R.).

Dr. HERBERT FRIEDMAN, Superintendent, Space Science Division, U.S. Naval Research Laboratory, Washington, D.C.

Dr. EDWIN L. GOLDWASSER, Deputy Director, National Accelerator Laboratory, Batavia, Ill.

Dr. JANE H. HALL, Assistant Director, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. STEPHEN LAWROSKI, Associate Director, Argonne National Laboratory, Argonne, Ill.

LOMBARD SQUIRES, Manager, Atomic Energy Division, E. I. Du Pont de Nemours & Co., Wilmington, Del.

HOWARD G. VESPER, retired (formerly Vice President, Standard Oil Co. of California, San Francisco, Calif.).

WILLIAM WEBSTER, Chairman, New England Electric System, Boston, Mass.

Dr. MELVIN A. HARRISON, Scientific Officer; Lawrence Radiation Laboratory, Livermore, Calif.

ANTHONY A. TOMEI, *Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee met four times in 1968: in Berkeley, Calif., on January 24–26; in Washington, D.C. on May 6–8; at Argonne, Ill., on July 8–11; and in Washington, D.C. on October 14–16, 1968.

Patent Compensation Board

This board was established in April 1949 pursuant to Section 11 of the Atomic Energy Act of 1946, and is the board designated under Section 157a of the Atomic Energy Act of 1954. Section 157 provides that upon application for just compensation or awards or for the determination of a reasonable royalty fee, certain proceedings shall be held before such a board.

ROBERT C. WATSON, *Chairman;* firm of Watson, Cole, Grindle & Watson, Washington, D.C.

DOUGLAS MCLEOD COOMBS, Simmonds Precision Products, Inc., Tarrytown, N.Y.

MALCOLM W. FRASER, 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 Washington, D.C., on April 16–18 and October 21–23.

Advisory Committee on Reactor Safeguards

The committee, 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. CARROLL W. ZABEL, *Chairman;* Director of Research and Associate Dean of the Graduate School, University of Houston, Houston, Tex.

Dr. STEPHEN H. HANAUER, *Vice Chairman;* Professor of Nuclear Engineering, University of Tennessee, Knoxville, Tenn.

Dr. SPENCER H. BUSH, Consultant to the Director (Metallurgy), Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Wash.

HAROLD ETHERINGTON, Consulting Engineer (Mechanical Reactor Engineering), Jupiter, Fla.

Dr. WILLIAM L. FAITH, Consultant (Air Pollution Control), San Marino, Calif.

Dr. JOSEPH M. HENDRIE, Physicist, Brookhaven National Laboratory, Upton, N.Y.

Dr. HERBERT S. ISBIN, Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn.

HAROLD G. MANGELSDORF, Chairman of the Board, Crown Central Petroleum Corp., Short Hills, N.J.

Dr. HARRY O. MONSON, Senior Engineer, Laboratory Director's Office, Argonne National Laboratory, Argonne. Ill.

Dr. ARLIE A. O'KELLY, Consultant (Chemical Engineering), Littleton, Colo.

Dr. DAVID OKRENT, Senior Physicist, Laboratory Director's Office, Argonne National Laboratory, Argonne, Ill.

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, Manager, Atomic Energy Division, E. I. du Pont de Nemours & Co., Wilmington, Del.

Dr. WILLIAM R. STRATTON, Physicist, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

During 1968, the committee met 14 times: January 11–13, February 8–10, March 7–9, April 4–6, April 27, May 9–11, June 5–8, July 11–13, July 21, August 8–10, September 5–7, October 3–5, October 31–November 2, and December 5–7, all in Washington, D.C.

Atomic Safety and Licensing Board Panel

Section 191 of the Atomic Energy Act of 1954 authorizes, in addition to other matters, the Commission to establish one or more atomic safety and licensing boards, each to be composed of three members, two of whom are to be technically qualified and one of whom is to be qualified in the conduct of administrative proceedings. Technically qualified alternates may be appointed to atomic safety and licensing boards, to serve in the event that a board member should become unavailable before the start of a hearing. The boards conduct such hearings as the Commission may direct and make such intermediate or final decisions as it may authorize in proceedings with respect to granting, suspending, revoking, or amending licenses or authorizations. The Commission has appointed the following panel to serve on atomic safety and licensing board as assigned.

A. A. WELLS, *Panel Chairman,* U.S. Atomic Energy Commission, Washington, D.C.

J. D. BOND, Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

R. B. BRIGGS, Director, Molten Salt Reactor Program, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. JOHN HENRY BUCK, Group Vice President, Automation Industries, Inc., Los Angeles, Calif.

Dr. A. DIXON CALLIHAN, Union Carbide Corp., Oak Ridge, Tenn.

JACK M. CAMPBELL, Partner in law firm of Stephenson, Campbell & Olmstead, Santa Fe, N. Mex.

VALENTINE B. DEALE, Attorney-at-law, Washington, D.C.

Dr. MILTON C. EDLUND, Director, Middle East Study Group, Oak Ridge, Tenn.

Dr. ROLF ELIASSEN, Professor of Environmental Engineering, Stanford University, Palo Alto, Calif.

Dr. STUART GORDON FORBES, Assistant Manager, Technology, Atomic Energy Div., Phillips Petroleum Co., Idaho Falls, Idaho.

Dr. JOHN C. GEYER, Chairman, Department of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore, Md.

JAMES P. GLEASON, Attorney-at-law, Washington, D.C.

Dr. CLARK GOODMAN, Professor of Physics and Department Chairman, University of Houston, Houston, Tex.

Dr. EUGENE GREULING, Professor of Physics, Duke University, Durham, N.C.

Dr. DAVID B. HALL, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

SAMUEL W. JENSCH, Chief Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

ARTHUR W. MURPHY, Columbia University School of Law, New York City.

Dr. HUGH PAXTON, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. THOMAS H. PIGFORD, Professor of Nuclear Engineering, University of California, Berkeley, Calif.

Dr. LAWRENCE R. QUARLES, Dean, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va.

REUEL C. STRATTON, Consulting Engineer, Hartford, Conn.

Dr. CLARKE WILLIAMS, Research Administrator, Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board, Hauppauge, Long Island, N.Y.

Dr. CHARLES E. WINTERS, Parma Research Center, Union Carbide Corp., Cleveland, Ohio.

Dr. ABEL WOLMAN, The Johns Hopkins University, Baltimore, Md.

HOOD WORTHINGTON, retired, E. I. du Pont de Nemours Co. Scientist and Administrator, Wilmington, Del.

Seventeen new boards were drawn from the panel in 1968 for regulatory proceedings. A general ASLB Panel meeting was held with the AEC Commissioners on July 10–11 in the Chicago area, and numerous meetings on specific problems were held with groups of panel members throughout the year.

APPEALS BOARDS

Board of Contract Appeals

On August 25, 1964, the Commission established the AEC Board of Contract Appeals under the supervision of a chairman, who reports directly to the Commission. The Board of Contract Appeals considers and finally decides appeals from findings of fact or decisions of contracting officers in disputes arising under AEC prime contracts containing a disputes provision and certain subcontracts containing such a provision. The board, in addition, conducts hearings and finally decides debarment cases in which a hearing has been held. The rules of practice of the board were published in the *Federal Register* on September 11, 1964, and codified as part 3 of Title 10, Code of Federal Regulations.

PAUL H. GANTT, *Chairman;* U.S. Atomic Energy Commission, Washington, D.C.

JOHN G. ROBERTS, *Vice Chairman;* U.S. Atomic Energy Commission, Washington, D.C.

CARMINE S. BELLINO, Certified Public Accountant, Wright, Long & Co., Washington, D.C.

LAWRENCE R. CARUSO, Legal Counsel, Office of Research Administration, Princeton University, Princeton, N.J.

VALENTINE B. DEALE, Attorney at Law, Washington, D.C.

Dr. G. KENNETH GREEN, Chairman, Accelerator Department, Brookhaven National Laboratory, Upton, N.Y.

HENRY B. KEISER, Attorney at Law and President, Federal Publications, Inc., Washington, D.C.

LEONARD J. KOCH, Director, Reactor Engineering Division, Argonne National Laboratory, Argonne, Ill.

JOHN T. KOEHLER, Attorney at Law, Butler, Koehler & Tausig, Washington, D. C.

JOHN A. McINTIRE, Consulting Attorney, Office of Judge Advocate General, U.S. Navy, Washington, D.C.

RALPH C. NASH, Jr., Associate Dean for Graduate Studies, Research and Projects of National Law Center, George Washington University, Washington, D.C.

THOMAS J. O'TOOLE, Dean, Northeastern School of Law, Boston, Mass.

HAROLD C. PETROWITZ, Professor of Law, Washington College of Law, American University, Washington, D.C.

CHARLES G. SONNEN, Private Consultant, Oak Ridge, Tenn.

JOHN M. STOY, Certified Public Accountant, Stoy, Malone & Co., Washington, D.C.

ARLENE TUCK ULMAN, Attorney at Law, Washington, D.C.

ROBERT M. UNDERHILL, Vice President and Treasurer Emeritus, University of California, Berkeley, Calif.

CAPT. DANIEL B. VENTRES, Consulting Engineer, Haddam, Conn.

JOHN W. WHELAN, Professor of Law, University of California at Davis School of Law, Davis, Calif.

Several meetings of panels designated to hear, consider, and decide appeals were held during 1968.

ADVISORY BODIES TO THE ATOMIC ENERGY COMMISSION

Atomic Energy Labor-Management Advisory Committee

This 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.

GORDON M. FREEMAN, International President, International Brotherhood of Electrical Workers, Washington, D.C.

CHARLES D. HARRINGTON, President, Douglas United Nuclear, Inc., Richland, Wash.

CHARLES H. KEENAN, Vice President, Yankee Atomic Electric Co., Boston, Mass.

HOWARD K. NASON, President, Monsanto Research Corp., St. Louis, Mo.

P. L. SIEMILLER, International President, International Association of Machinists and Aerospace 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.

ELWOOD D. SWISHER, Vice President, Oil, Chemical and Atomic Workers International Union, Denver, Colo.

The committee met twice in 1968: on May 16 in Washington, D.C., and on October 9 in Las Vegas, Nev.

Advisory Committee for Biology and Medicine

The Advisory Committee for Biology and Medicine was created in September 1947 on the recommendation of the Commission's Medical Board of Review. The committee reviews the programs in medical and biological research and health and recommends to the Commission general policies in these fields.

Dr. EARL L. GREEN, *Chairman;* Director, The Jackson Laboratory, Bar Harbor, Maine

Dr. PHILIP P. COHEN, *Vice Chairman;* Professor and Chairman, Department of Physiological Chemistry, University of Wisconsin School of Medicine, Madison, Wis.

Dr. WILLIAM F. BALE, Professor, Radiation Biology, Department of Radiation Biology and Biophysics; and Atomic Energy Project, University of Rochester, School of Medicine and Dentistry, Rochester, N.Y.

Dr. ARIE J. HAAGEN-SMIT, Professor, Division of Biology, California Institute of Technology, Pasadena, Calif.

Dr. ROBERT D. MOSELEY, Jr., Chairman of Department of Radiology, University of Chicago, Chicago, Ill.

Dr. LEMUEL C. MCGEE, Medical Director, Hercules, Inc., Wilmington, Del.

Dr. MORRELL B. RUSSELL, Director, Agricultural Experiment Station, University of Illinois, Urbana, Ill.

Dr. HARVEY M. PATT, *Scientific Secretary,* Director, Laboratory of Radiobiology, San Francisco Medical Center, University of California, San Francisco, Calif.

ROSEMARY ELMO, *Executive Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee met six times during 1968: January 12–13, Washington, D.C.; March 8–9, Lansing, Mich.; May 10–11, Washington, D.C.; July 8, Argonne, Ill.; September 13–14, Washington, D.C.; November 7–9, Las Vegas, Nev.

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. GEORGE E. MOWRY, *Chairman;* Professor of History, University of North Carolina, Chapel Hill, N.C.

Dr. JAMES L. CATE, Professor of History, University of Chicago, Chicago, Ill.
Dr. A. HUNTER DUPREE, Professor of History, Brown University, Providence, R.I.
Dr. CONSTANCE McL. GREEN, Washington, D.C.
Dr. RALPH W. HIDY, Professor of Business History, Graduate School of Business Administration, Harvard University, Cambridge, Mass.
Dr. ISADORE PERLMAN, Associate Director, Lawrence Radiation Laboratory, Berkeley, Calif.
Dr. DON K. PRICE, Jr., Dean, John Fitzgerald Kennedy School of Government, Harvard University, Cambridge, Mass.
Dr. ROBERT R. WILSON, Director, National Accelerator Laboratory, Weston, Ill.
Dr. RICHARD G. HEWLETT, AEC representative, Chief Historian, U.S. Atomic Energy Commission, Washington, D.C.

The committee met in Washington, D.C. on May 13–14.

Advisory Committee on Isotopes and Radiation Development

This committee was established by the Commission in July 1958 to advise on means of encouraging wide-scale industrial use of radioisotopes and nuclear radiation.

JOHN W. LANDIS, *Chairman;* Regional Vice President, Gulf General Atomics, Inc., Washington, D.C.
Dr. NATHANIEL F. BARR, U.S. Atomic Energy Commission, Washington, D.C.
Dr. MILTON BURTON, Director of Radiation Laboratory, University of Notre Dame, Notre Dame, Ind.
Cmdr. SCOTT CARPENTER, U.S. Navy Dept., Chevy Chase, Md.
Dr. BERNARD FRIES, Senior Research Associate, Chevron Research Co., Richmond, Calif.
Dr. DAVID E. HARMER, Head, Gamma Radiation Section, Radiochemistry Research Laboratory, Dow Chemical Co., Midland, Mich.
ROBERT E. KETTNER, President, Nuclear Assurance Corp., Atlanta, Ga.
Dr. WILFRED R. KONNEKER, General Manager, Mallinckrodt/Nuclear, St. Louis, Mo.
Dr. JAMES R. MAXFIELD, Jr., Maxfield Clinic-Hospital, Dallas, Tex.
Dr. DONALD W. PRITCHARD, Director, Chesapeake Bay Institute, and Chairman, Department of Oceanography, Johns Hopkins University, Baltimore, Md.
Dr. VIVIAN T. STANNETT, Professor of Chemical Engineering, School of Engineering, University of North Carolina, Raleigh, N.C.
Dr. PAUL M. STIER, Program Manager—Corporation Research, Union Carbide Corp., Tarrytown, N.Y.

The committee met once during 1968: March 14–15 at Upton, N.Y.

Advisory Committee on Medical Uses of Isotopes

The committee was established in 1958 and replaced the Subcommittee on Human Applications of the Advisory Committee on Isotope Distribution. The committee advises the Commission on policies and standards for the regulation and licensing of medical uses of radioisotopes in humans.

Dr. JOHN A. McBRIDE, *Chairman;* Director, Division of Materials Licensing, U.S. Atomic Energy Commission, Washington, D.C.
Dr. MERRILL A. BENDER, Chief, Department of Nuclear Medicine, Roswell Park Memorial Institute, Buffalo, N.Y.
Dr. JOHN E. CHRISTIAN, Head of Bionucleonics, Purdue University, Lafayette, Ind.
Dr. E. RICHARD KING, Professor of Radiology, Medical College of Virginia, Richmond, Va.
Dr. DAVID E. KUHL, Associate Professor of Radiology, University of Pennsylvania, School of Medicine, Philadelphia, Pa.
Dr. GEORGE V. LEROY, Medical Director, Metropolitan Hospital, Detroit, Mich.
Dr. RULON W. RAWSON, Dean of Medicine and Vice President, New Jersey College of Medicine and Dentistry, Jersey City, N.J.
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.

The committee met once during 1968, on March 23 in Washington, D.C.

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.

Mr. WILLARD BASCOM, President, Ocean Science and Engineering, Inc., Washington, D.C.

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.

Mr. 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, Yale University, New Haven, Conn.

Dr. HYMER L. FRIEDELL, Western Reserve University, Cleveland, Ohio.

Lt. Gen. ALFRED D. STARBIRD, Manager, U.S. Army Sentinel Systems Office, Alexandria, Va.

JOHN S. KELLY, *Secretary*, Director, Division of Peaceful Nuclear Explosives, U.S. Atomic Energy Commission, Washington, D.C.

The committee met twice during 1968: on April 15–16, 1968, at the Nevada Operations Office, Las Vegas, Nev., and on November 21 and 22, 1968, at the Oak Ridge National Laboratory, Oak Ridge, Tenn.

Advisory Committee on Reactor Physics

This committee 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. IRA F. ZARTMAN, *Chairman;* Division of Reactor Development and Technology, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ROBERT AVERY, Director, Reactor Physics Division, Argonne National Laboratory, Argonne, Ill.

Dr. ROBERT BAYARD, Westinghouse Electric Corp., Bettis Atomic Power Div., Pittsburgh, Pa.

JACK CHERNICK, Associate Head, Reactor Physics Division, Brookhaven National Laboratory, Upton, N.Y.

Dr. E. RICHARD COHEN, Associate Director, North American Aviation Science Center, Thousand Oaks, Calif.

FRANK G. DAWSON, Jr., Manager, Physics and Engineering Div., Pacific Northwest Laboratory, Richland, Wash.

Dr. GERHARD DESSAUER, Director, Physics Section, Savannah River Laboratory, Aiken, S.C.

Dr. RICHARD EHRLICH, Manager, Advanced Development Activity, Knolls Atomic Power Laboratory, Schenectady, N.Y.

Dr. REX FLUHARTY, Los Alamos, N. Mex.

Dr. E. R. GAERTTNER, Director, Linac Project, Rensselaer Polytechnic Institute, Troy, N.Y.

HARVEY GRAVES, Jr., Associate Professor, The University of Michigan College of Engineering, Ann Arbor, Mich.

Dr. GORDON HANSEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. W. B. LOEWENSTEIN, LMFBR Program Office, Argonne National Laboratory, Argonne, Ill.

Dr. F. C. MAIENSCHEIN, Associate Director, Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. LOTHAR W. NORDHEIM, Chairman, Theoretical Physics Department, General Atomic, San Diego, Calif.

Dr. THOMAS M. SNYDER, Atomic Products Division, General Electric Co., Pleasanton, Calif.

Dr. ALVIN RADKOWSKY, *Secretary;* Division of Naval Reactors, U.S. Atomic Energy Commission, Washington, D.C.

The committee met twice during 1968: on February 6-8 at the National Reactor Testing Station, Idaho Falls, Idaho; on May 20-21 at Pacific Northwest Laboratory near Richland, Wash.

Advisory Committee on Nuclear Materials Safeguards

The committee was established August 29, 1967, to assist the Atomic Energy Commission in carrying out more effectively its responsibilities for safeguarding special nuclear materials under the Atomic Energy Act. The committee will advise 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 will provide 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 (Mr. Palfrey served as a member of the Atomic Energy Commission, 1962–1966)

Brig. Gen. DELMAR L. CROWSON (USAF, Ret.), *Vice Chairman;* Director, Office of Safeguards and Materials Management, U.S. Atomic Energy Commission, Washington, D.C.

Dr. RUSSELL P. WISCHOW, *Vice Chairman;* Director, Division of Nuclear Materials Safeguards, U.S. Atomic Energy Commission, Washington, D.C.

ROGER E. BATZEL, Associate Director, Lawrence Radiation Laboratory, Livermore, Calif.

FRANCIS P. COTTER, Vice President, Westinghouse Electric Corp., Washington, D.C.

PAUL GRADY, consultant to accounting firm of Price-Waterhouse Co., New York City

Dr. JANE HALL, Associate Director, Los Alamos (N. Mex.) Scientific Laboratory

Dr. RALPH F. LUMB, Director, Western New York Nuclear Research Center, Buffalo, N.Y.

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.

CLEMENT J. RODDEN, Manager, AEC's New Brunswick (N.J.) Area Office and Director of the New Brunswick Laboratory.

LOUIS H. RODDIS, Jr., Chairman of the Board, Pennsylvania Electric Co., and Director of Nuclear Power Activities for General Public Utilities Corp., of New York City

WALTON A. RODGER, past Associate Director, Chemical Engineering Division, Argonne (Ill.) National Laboratory and now on the staff of Nuclear Safety Associates in Bethesda, Md.

LOMBARD SQUIRES, Manager, Atomic Energy Div., E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

CHARLES D. W. THORNTON, Executive Vice President, Clevepak Corp., Cleveland, Ohio.

Dr. FRED H. TINGEY, Manager of Operations Analysis, Idaho Nuclear Corp., Idaho Falls, Idaho.

FRANCIS O. WILCOX, Dean, School of Advanced International Studies, Johns Hopkins University, Baltimore, Md.

J. ERNEST WILKINS, Jr., Assistant Director, Gulf General Atomics, Inc., San Diego, Calif.

The committee established from its own membership three standing subcommittees: the International Subcommittee, the Research and Development Subcommittee, and the Regulatory Subcommittee. The International and Research and Development Subcommittees met in the AEC offices in Washington on January 22 and the Research and Development and Regulatory Subcommittees met in the AEC offices in Washington on May 27. The Research and Development Subcommittee had its third meeting in the Livermore Laboratory, Livermore, Calif. on September 10. The full committee held three meetings during the year, all in the AEC offices in Washington and Germantown, Md.: January 23–24; May 28–29; and October 17-18.

Advisory Committee on Technical Information

This commitee 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.

CARROLL G. BOWEN, Director, the M.I.T. Press, Massachusetts Institute of Technology, Cambridge, Mass.

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, Editor, "Metal Progress," American Society for Metals, Metals Park, Ohio.

FRED P. PETERS, Executive Vice President, Reinhold Publishing Corp., New York, N.Y.

KARL T. SCHWARTZWALDER, Director of Research, A-C Spark Plug Division, General Motors Corp., Flint, Mich., representing the American Ceramic Society, Inc., Columbus, Ohio.

OLIVER H. TOWNSEND, Chairman, New York State Atomic and Space Development Authority, New York, N.Y.

JOHN W. WIGHT, Vice President for Marketing, McGraw-Hill Book Co., Inc., New York, N.Y.

The committee, as a whole, did not meet in 1968; its Technical Book and Monograph Subcommittee met in New York City on March 20, and its Exhibits and Educational Subcommittee met in San Juan, P.R., on May 9–10.

Technical Information Panel

The 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.

ROBERT A. BENSON, Technical Editor, Monsanto Research Corp., Mound Laboratory, Miamisburg, Ohio.

CLARENCE T. BROCKETT, Head, Technical Information Department, Lawrence Radiation Laboratory, Livermore, Calif.

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.

W. A. MINKLER, Supervisor, Bettis Technical Information, Westinghouse Electric Corp., West Mifflin, Pa.

Dr. JUDD C. NEVENZEL, University of California, Laboratory of Nuclear Medicine, Los Angeles, Calif.

STEWARD W. O'REAR, Supervisor, Technical Information Service, Savannah River Laboratory, Aiken, S.C.

A. D. PEPMUELLER, Manager, Technical Information Department, Sandia Corp., Livermore, Calif.

DENNIS PULESTON, Head, Information Division, Brookhaven National Laboratory, Upton, N.Y.

HELEN F. REDMAN, Librarian, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

C. G. STEVENSON, Technical Information Section Manager, Pacific Northwest Laboratory, Richland, Wash.

Dr. STUART STURGES, Manager, Technical Information, Knolls Atomic Power Laboratory, Schenectady, N.Y.

CHARLES D. TABOR, Assistant Manager, Technical Division, Goodyear Atomic Corp., Piketon, Ohio.

JOSEPH W. VOTAW, Assistant to Technical Director, National Lead Co. of Ohio, Cincinnati, Ohio.

Dr. RAYMOND K. WAKERLING, Chief, Technical Information Division, Lawrence Radiation Laboratory, Berkeley, Calif.

ROBERT L. SHANNON, *Secretary;* Ext. Manager, Division of Technical Information Extension, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

The panel met twice during 1968: in May in New York City, and in November in Bethesda, Md.

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Committee of Senior Reviewers

The Committee of Senior Reviewers studies the major technical activities of the Atomic Energy Commission program and advises the Commission on classification and declassification matters, making recommendations with respect to the classification rules and guides for the control of scientific and technical information.

Dr. WARREN C. JOHNSON, *Chairman;* retired Vice President for Special Scientific Programs, University of Chicago, Chicago, Ill.

Dr. JESSE W. BEAMS, Professor of Physics, University of Virginia, Charlottesville, Va.

Dr. EUGENE EYSTER, Alternate GMX Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

ROBERT W. HENDERSON, Vice President, Sandia Corp., Albuquerque, N. Mex.

Dr. J. CARSON MARK, T Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. J. REGINALD RICHARDSON, Professor of Physics, University of California at Los Angeles, Calif.

Dr. JACK W. ROSENGREN, Associate Director for Nuclear Design, Lawrence Radiation Laboratory, Livermore, Calif.

PAUL R. VANSTRUM, Principal Scientist—Production, Union Carbide Corporation, Oak Ridge, Tenn.

The committee met on May 27–29, 1968 for a 2-day session at the Lawrence Radiation Laboratory and a 1-day session in Berkeley, Calif. In addition, the committee made orientation trips during the year to plants and facilities located in Oak Ridge, Tenn.; Aiken, S.C.; St. Petersburg, Fla.; Kansas City, Mo.; and Rocky Flats, Colo.

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. MARIO L. JUNCOSA, *Chairman;* The Rand Corp., Santa Monica, Calif.

Prof. FREDERICK P. BROOKS, Univ. of North Carolina, Chapel Hill, North Carolina.

Dr. BENGT G. CARLSON, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

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. PAUL R. GARABEDIAN, AEC Computing and Applied Mathematics Center, Courant Institute of Mathematical Sciences, New York University, N.Y.

Prof. MARTIN GRAHAM, Univ. of California, Berkeley, Calif.

Dr. J. WALLACE GIVENS, Jr., Applied Mathematics Division, Argonne National Laboratory, Argonne, Ill.

Dr. ALSTON S. HOUSEHOLDER, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. CHARLES V. L. SMITH, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

Dr. YOSHIO SHIMAMOTO, *Secretary;* Brookhaven National Laboratory, Upton, N.Y.

The committee met once during 1968: on May 9 at Urbana, Ill.

Nuclear Cross Sections Advisory Committee

This committee provides consultation and guidance for the Commission's program of nuclear cross-section measurements. Information from this program is of fundamental importance to many activities of the AEC.

Dr. HENRY T. MOTZ, *Chairman;* Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. HARRY ALTER, Atomics International, Canoga Park, Calif.

Dr. ROBERT M. BRUGGER, Idaho Nuclear Corp., Idaho Falls, Idaho.

Dr. R. E. CHRIEN, Brookhaven National Laboratory, Upton, N.Y.

Dr. FRANK FEINER, Knolls Atomic Power Laboratory, Schenectady, N.Y.

Prof. HERBERT GOLDSTEIN, Columbia University, New York, N.Y.

Dr. EUGENE HADDAD, Defense Atomic Support Agency, Washington, D.C.

PHILIP B. HEMMIG, Division of Reactor Development and Technology, U.S. Atomic Energy Commission, Washington, D.C.

Dr. HAROLD E. JACKSON, Argonne National Laboratory, Argonne, Ill.

Dr. HARRY H. LANDON, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C.

Prof. HENRY W. NEWSON, Duke University, Durham, N.C.

Prof. GERALD C. PHILLIPS, Rice University, Houston, Tex.

Dr. GEORGE L. ROGOSA, Chief, Physics Branch, P&M Programs, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.
Prof. ERWIN F. SHRADER, Case-Western Reserve University, Cleveland, Ohio.
Dr. PAUL H. STELSON, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Dr. M. S. MOORE, *Secretary*, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

The committee met twice during 1968: on April 3–4 at Los Alamos, N. Mex., and on October 21–23 at Columbia University, N.Y.

High Energy Physics Advisory Panel

This advisory panel was established in November 1966 pursuant to the provisions of Section 161a of the Atomic Energy Act, to review on a continuing basis, the High Energy Physics Research Program and to provide advice and recommendations to the Division of Research with respect to this program.

Prof. VICTOR F. WEISSKOPF, *Chairman;* Massachusetts Institute of Technology, Cambridge, Mass.
Dr. RODNEY L. COOL, Brookhaven National Laboratory, Upton, N.Y.
Prof. EARLE C. FOWLER, Duke University, Durham, N.C.
Prof. LEON LEDERMAN, Nevis Laboratories, Columbia University, Irvington, N.Y.
Dr. EDWARD J. LOFGREN, Lawrence Radiation Laboratory, Berkeley, Calif.
Dr. GEORGE E. PAKE, Washington University, St. Louis, Mo.
Prof. W. K. H. PANOFSKY, Stanford Linear Accelerator Center, Stanford University, Stanford, Calif.
Prof. ROBERT G. SACHS, Argonne National Laboratory, Argonne, Ill.
Prof. KEITH R. SYMON, University of Wisconsin, Madison, Wis.
Prof. KENT TERWILLIGER, University of Michigan, Ann Arbor, Mich.
Prof. ROBERT L. WALKER, California Institute of Technology, Pasadena, Calif.
Prof. C. N. YANG, State University of New York, Stony Brook, N.Y.
Dr. BERNARD HILDEBRAND, *Executive Secretary;* Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

The panel met five times during 1968: January 19–20 at Washington, D.C.; April 20–21 at Princeton, N.J.; June 20–21 at Washington, D.C.; October 4–5 at Cambridge, Mass.; and December 6–7 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 ensure closer cooperative effort within the program and to provide guidance on implementing major program decisions. The committee has four members who are directors of the controlled thermonuclear research in their respective laboratories, and four members from the scientific community outside of the AEC and its major laboratories.

Dr. AMASA S. BISHOP, *Chairman;* Assistant Director for Controlled Thermonuclear Research, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.
Dr. KEITH A. BRUECKNER, University of California, San Diego, Calif.
Dr. SOLOMON J. BUCHSBAUM, Sandia Corp., Albuquerque, N. Mex.
Dr. WILLIAM A. FOWLER, California Institute of Technology, Pasadena, Calif.
Dr. MELVIN B. GOTTLIEB, Plasma Physics Laboratory, Princeton University, Princeton, N.J.
Dr. HAROLD LEWIS, University of California, Santa Barbara, Calif.
Dr. HERMAN POSTMA, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Dr. RICHARD F. TASCHEK, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. CHESTER VAN ATTA, Lawrence Radiation Laboratory, Livermore, Calif.

The committee met four times during 1968: March 1–2 at Santa Barbara, Calif.; May 23–24 at Oak Ridge, Tenn.; September 26–27 at Los Alamos, N. Mex.; and December 11–12 at Livermore, Calif.

Personnel Security Review Board

This board was appointed in March 1949 primarily to review specific personnel security cases which arise under the Commission's administrative review procedure and to make recommendations concerning them to the General Manager. 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 three cases during 1968.

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. MORTON SMUTZ
Assistant Director .... Dr. ADOLPH F. VOIGT

ARGONNE NATIONAL LABORATORY (University of Chicago and Argonne Universities Association, contractors), Argonne, Ill.

Director .... Dr. ROBERT B. DUFFIELD
Associate Director .... Dr. WINSTON M. MANNING
Associate Director .... Dr. STEPHEN LAWROSKI
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. HOWARD R. BOWEN
President .... Dr. PHILIP N. POWERS

BETTIS ATOMIC POWER LABORATORY (Westinghouse Electric Corp., contractor), Pittsburgh, Pa.

General Manager .... N. A. BELDECOS
Manager, Operations .... E. J. KREH
Manager, Operating Plants .... W. H. HAMILTON

BROOKHAVEN NATIONAL LABORATORY (Associated Universities, Inc., contractor), Upton, N.Y.

Laboratory Director .... Dr. MAURICE GOLDHABER
Deputy Director .... Dr. GEORGE VINEYARD
Associate Director .... Dr. VICTOR P. BOND
Associate Director .... Dr. RODNEY L. COOL

Associated Universities, Inc. [2]

Chairman, Board of Trustees .... Dr. F. A. LONG
President, AUI .... Dr. F. A. LONG (Acting)

BURLINGTON AEC PLANT (Mason & Hanger-Silas Mason Co., Inc., contractor) Burlington, Iowa

Contract Manager (Vice President) .... R. B. JEWELL
Plant Manager .... D. E. HEFFELBOWER
Administration & Services Division Manager .... R. S. RAMSEY
Engineering Division Manager .... C. R. POOLE
Manufacturing, Division A Manager .... F. J. BRODSKY
Manufacturing, Division B Manager .... P. D. HOLLIDAY

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[1] Installations and prime contractors where the AEC's total combined investment in plant and equipment exceeds $25 million are listed here. Other research and development installations are listed in app. 1 of the supplementary report, "Fundamental Nuclear Energy Research—1968."

[2] Associations or groups of educational institutions participating in AEC facility operations or programs are listed in app. 1 of the supplementary report, "Fundamental Nuclear Energy Research—1968."

CAMBRIDGE ELECTRON ACCELERATOR (Massachusetts Institute of Technology and Harvard University, contractor), Cambridge, Mass.

Director	Dr. KARL STRAUCH
Assistant Director	Dr. GUSTAV A. VOSS
Assistant Director	(Vacancy)
Assistant Director	(Vacancy)
Business Manager	WILLIAM B. BALCH

FEED MATERIALS PROUCTION CENTER (National Lead Co. of Ohio, contractor), Fernald, Ohio

Manager	JAMES H. NOYES
Assistant Manager	M. S. NELSON

HANFORD FACILITIES (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, United States Testing Co., Inc.), Richland, Wash.

Atlantic Richfield Hanford Co., Richland, Wash.

President	Dr. L. M. RICHARDS
Vice President, Operations	R. P. CORLEW
Vice President, Business Management	J. M. SCHULTZ

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. C. D. HARRINGTON
Vice President and Deputy Gen. Manager	RAYMON W. HALLET, Jr.
Vice President and Asst. Gen. Manager for Operation Division	O. C. SCHROEDER
Vice President and Asst. Gen. Manager for Technical Division	Dr. C. W. KUHLMAN
Director, Employee Relations and Counsel	W. A. CATTS
Director, Finance and Administration Division	K. L. ROBERTSON

Hanford Engineering Services, Richland, Wash.

President	J. M. FRAME
General Manager	GEORGE KLIGFIELD

Hanford Environmental Health Foundation, Richland, Wash.

Medical Director	P. A. FUQUA, M.D.
Asst. Medical Director	G. H. CROOK, M.D.
Manager, Finance and Contract Administration	A. R. ADELINE
Manager, Environment Sciences Department	F. E. ADLEY

ITT Federal Support Services, Richland, Wash.

Executive Vice President and General Manager	T. P. LEDDY
Manager, Purchasing and Stores	W. M. HUNT
Manager, Transportation and Maintenance	M. F. RICE
Manager, Plant Protection, Services, and Utilities	C. W. WEEKS

J. A. Jones Construction Co., Richland, Wash.

General Manager and Vice President	IRA E. DUNN
Assistant Manager	D. L. SHORT

Pacific Northwest Laboratory (Battelle-Northwest Division of Battelle Memorial Institute, Columbus, Ohio, contractor), Richland, Wash.

Director	Dr. F. W. ALBAUGH
Associate Director	W. D. RICHMOND
Assistant Director, Finance and Administration Division	WALLACE SALE
Assistant Director, Safety and Standards Division	Dr. J. J. CADWELL
Assistant Director, Sponsor and Staff Relations Division	C. R. TIPTON, Jr.
Assistant Director, Technical Services Division	F. W. WOODFIELD

Chief Counsel, Legal Office	P. T. SANTILLI
Manager, Chemistry and Metallurgy Division	Dr. D. R. DE HALAS
Manager, Environmental and Life Sciences Division	H. M. PARKER
Manager, Fast Flux Test Facility Division	E. R. ASTLEY
Manager, Physics and Engineering Division	F. G. DAWSON
Manager, Systems and Electronics Division	Dr. C. A. BENNETT

United States Testing Co., Inc., Richland, Wash.

General Manager	D. B. WILCOX
Manager, Dosimetry Services	R. L. PIERCE
Manager, Radiochemistry	D. P. ARGYLE
Manager, Engineering Services	N. W. HAAGENSON

KANSAS CITY PLANT (The Bendix Corp., Kansas City Division, contractor) Kansas City, Mo.

General Manager	R. J. QUIRK
Assistant General Manager	V. L. RITTER
Director, Manufacturing	F. J. TAYLOR
Director, Engineering	D. J. NIGG

KNOLLS ATOMIC POWER LABORATORY (General Electric Co., contractor) Schenectady, N.Y.

General Manager	H. E. STONE
Manager, A1G Project	C. S. HOFMANN
Manager, Nuclear Plant Engineering	E. C. RUMBAUGH
Manager, Operating Nuclear Plants	D. J. ANTHONY
Manager, Kesselring Site Operation	L. H. WEINBERG

E. O. LAWRENCE RADIATION LABORATORY (University of California, contractor), facilities at Berkeley and Livermore, Calif.

Director	Dr. EDWIN M. MCMILLAN
Director, Livermore Laboratory	Dr. MICHAEL M. MAY
Business Manager	RICHARD P. CONNELL
Deputy Business Manager	WILLIAM B. HARFORD

Associate Directors, Berkeley:

Donner Laboratory of Medical Physics, Director	Dr. JOHN H. LAWRENCE
Inorganic Materials Research Division	Dr. LEO BREWER
Laboratory of Chemical Biodynamics, Director	Dr. MELVIN CALVIN
Nuclear Chemistry Division	Dr. ISADORE PERLMAN
Physics Division	Dr. DAVID L. JUDD
Program and Planning	Dr. ROBERT L. THORNTON
Administration	Dr. HAROLD A. FIDLER
Support	Dr. ELMER L. KELLY

Associate Directors, Livermore:

Advanced Studies	Dr. ARTHUR T. BIEHL
Biomedical Research	Dr. JOHN W. GOFMAN
Chemistry	Dr. ROGER E. BATZEL
Military Application	Dr. CHARLES A. MCDONALD
Nuclear Design	Dr. ROLAND F. HERBST
Nuclear Testing	Dr. HARRY L. REYNOLDS
Physics	Dr. EDWARD TELLER
Plans	A. CARL HAUSSMANN
Plowshare	Dr. GLENN C. WERTH
Sherwood	Dr. CHESTER M. VAN ATTA
Special Projects	Dr. JACK W. ROSENGREN
Support	DUANE C. SEWELL

LOS ALAMOS SCIENTIFIC LABORATORY (University of California, contractor), Los Alamos, N. Mex.

Director	Dr. NORRIS E. BRADBURY
Technical Associate Director	Dr. RAEMER E. SCHREIBER
Assistant Director	Dr. JANE H. HALL
Assistant Director, Production	Dr. MAX F. ROY
Assistant Director, Classification and Security	PHILLIP F. BELCHER
Assistant Director, Financial Planning	LESLIE G. HAWKINS
Assistant Director, Administration	HENRY R. HOYT

MOUND LABORATORY (Monsanto Research Corp., contractor), Miamisburg, Ohio

Project Director (President, Monsanto Research Corp.) — H. K. Nason
Director, Mound Laboratory — Ralph L. Neubert
Director, Nuclear Operations — G. Richard Grove
Director, Explosives Operations — J. E. Bradley

NATIONAL REACTOR TESTING STATION (NRTS) (five contractors—Argonne National Laboratory, General Electric, Idaho Nuclear, Phillips, and Westinghouse), Idaho Falls, Idaho

Argonne National Laboratory (Idaho Facilities), Idaho Falls

Assistant Laboratory Director — Meyer Novick
Assistant Business Manager — Donald F. Wood
Deputy Director, Reactor Physics Division — Frederick W. Thalgott
EBR-2 Reactor Operations Superintendent — Dr. Harry Lawroski

General Electric Co. (Idaho Test Station, Nuclear Systems Programs), Idaho Falls

Manager — Dr. J. W. Morfitt
Manager, Development and Test Engineering — L. S. Masson
Manager, Relations and Services — L. A. Munther
Manager, Operations and Analysis — Dr. J. F. Kunze
Manager, Nuclear Safety — R. B. O'Brien
Manager, Projects Analysis — F. O. Urban

General Electric Co. (Knolls Atomic Power Laboratory, S5G Field Office), Idaho Falls

Manager, S5G Test Plant Site — E. H. Schoch

Idaho Nuclear Corp. (Jointly owned subsidiary of Aerojet General Corp. and Allied Chemical Corp.), Idaho Falls

Manager — Dr. J. B. Philipson
Deputy Manager — F. H. Anderson
Manager, Administrative Division — R. Tripp
Manager, Engineering Division — L. J. Weber
Manager, Nuclear and Chemical Technology Division — D. R. DeBoisblanc
Acting Manager, Operations Division — F. H. Anderson

Phillips Petroleum Co. (Atomic Energy Division), Idaho Falls

Manager — J. P. Lyon
Assistant Manager, Technical — Dr. S. G. Forbes
Assistant Manager, Administration — L. L. Leedy
Manager, Water Reactor Safety Program Office — G. O. Bright
Manager, LOFT Program — T. R. Wilson
Manager, Power Burst Facility — R. S. Kern
Manager, SPERT — S. O. Johnson
Manager, Plant Applications and Engineering Tests — N. K. Sowards
Manager, Instrument Development — R. G. Morrison
Manager, Computer Sciences — B. M. Beardsley
Manager, Engineering — R. E. Boyar

Westinghouse Electric Corp., Idaho Falls

Manager, Naval Reactors Facility — H. D. Ruppel

NEVADA TEST SITE (Reynolds Electrical & Engineering Co., contractor), Mercury, Nev.

General Manager — J. R. Crockett
Deputy General Manager — R. W. Kiehn
Administration Division — R. E. Gillett
Program Control Division — W. A. Stevens
Operations Division — R. D. Cunningham
Site Facilities Division — R. A. Smith

NUCLEAR ROCKET DEVELOPMENT STATION (Los Alamos Scientific Laboratory, Pan American World Airways, Inc., Westinghouse Electric Corp., contractor), Jackass Flats, Nev.

OAK RIDGE RESEARCH AND DEVELOPMENT AND PRODUCTION FACILITIES (Union Carbide Corp., Nuclear Division, contractor), Oak Ridge, Tenn., and Paducah, Ky.

President, Union Carbide Corp., Nuclear Division ------ Dr. C. E. Larson

Oak Ridge Production Facilities

Vice President—Production, Union Carbide Corp., Nuclear Division and Superintendent, Y-12 Plant -- R. F. Hibbs
Deputy Superintendent, Y-12 Plant ------ J. M. Case
Superintendent, Oak Ridge Gaseous Diffusion Plant ------ Robert G. Jordan
Superintendent, Paducah Gaseous Diffusion Plant -- Robert A. Winkel

Oak Ridge National Laboratory

Director (Vice President, Union Carbide Corp., Nuclear Division) ------ Dr. Alvin M. Weinberg
Deputy Director ------ Dr. H. G. MacPherson

PANTEX PLANT (Mason & Hanger-Silas Mason Co., contractor), Amarillo, Tex.

Contract Manager (Vice President) ------ R. B. Jewell
Plant Manager ------ John C. Drummond
Division Manager, Engineering ------ Marion L. Ott
Division Manager, Manufacturing ------ Robert B. Carroll

PORTSMOUTH GASEOUS DIFFUSION PLANT (Goodyear Atomic Corp., contractor), Piketon, Ohio

General Manager ------ C. H. Reynolds
Deputy General Manager ------ Charles Tabor

PRINCETON-PENNSYLVANIA ACCELERATOR (Princeton University and University of Pennsylvania, contractors), James Forrestal Research Center, Princeton, N.J.

Director ------ Dr. Milton G. White
Associate Director ------ Dr. Walter Wales
Assistant Director ------ Dr. Alfred K. Mann

PRINCETON PLASMA PHYSICS LABORATORY (Princeton University, contractor), James Forrestal Research Center, Princeton, N.J.

Director ------ Dr. Melvin B. Gottlieb
Associate Director ------ Dr. Edward A. Frieman
Assistant Director ------ Dr. E. C. Tanner
Head, Experimental Division ------ Dr. Tom Stix
Head, Engineering and Development Division ------ Dr. Robert Mills
Head, Theoretical Division ------ Dr. J. M. Dawson
Head, Administrative Division ------ Robert Von Verdo

ROCKY FLATS PLANT (Dow Chemical Co., contractor), Rocky Flats, Colo.

General Manager ------ Dr. Lloyd M. Joshel
Facilities Manager ------ Doyle M. Bassler
Quality Manager ------ Herbert E. Bowman
Controller ------ Clement H. Dompierre
Manufacturing Manager ------ John G. Epp
Industrial Relations Manager ------ Charles M. Love
Director of Research and Development ------ L. A. Matheson
Division Services Manager ------ Edward J. Walko

SANDIA LABORATORY (Sandia Corp., contractor), facilities at Sandia Base, Albuquerque, N. Mex.; Livermore, Calif.; and Tonopah, Nev.

President ------ J. A. Hornbeck
Vice President ------ W. J. Howard
Vice President ------ R. W. Henderson
Vice President ------ R. B. Powell
Vice President ------ C. W. Campbell
Vice President ------ T. B. Cook, Jr.
Vice President ------ C. T. Ross, Jr.
Vice President ------ R. A. Bice
Vice President ------ S. J. Buchsbaum
Vice President ------ G. A. Fowler

SAVANNAH RIVER PLANT (E. I. du Pont de Nemours & Co., contractor), Aiken, S.C.

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	F. E. KRUESI
Assistant Director	C. H. ICE
Section Director—Physics Section	G. DESSAUER
Section Director, Separations Chemistry and Engineering Section	L. H. MEYER
Section Director—Nuclear Engineering and Materials Section	E. C. NELSON
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	MATTHEW L. SANDS
Associate Director, Technical Division	RICHARD B. NEAL
Associate Director, Research Division	JOSEPH BALLAM
Associate Director, Business Services Division	FREDERICK V. L. PINDER
Associate Director, Administrative Services Division	ROBERT H. MOULTON, Jr.

APPENDIX 4

ANNOUNCED DEFENSE-RELATED UNDERGROUND NUCLEAR DETONATIONS, 1968 [1]

Name	Date	Yield [2]
Crosstic Series (January-June)		
1. Hupmobile	Jan. 18	Low.
2. Staccato	Jan. 19	Low intermediate.
3. Faultless [3]	do	Intermediate.
4. Knox	Feb. 21	Low intermediate.
5. Dorsal Fin [4]	Feb. 29	Low.
6. Pommard	Mar. 14	Low.
7. Stinger [5]	Mar. 22	Low intermediate.
8. Milk Shake [4]	Mar. 25	Low.
9. Noor	Apr. 10	Low intermediate.
10. Shuffle	Apr. 18	Do.
11. Scroll [5] [6]	Apr. 23	Low.
12. Boxcar [5]	Apr. 26	Low megaton.
13. Clarksmobile	May 17	Low intermediate.
14. Tub	June 6	Low.
15. Rickey [5]	June 15	Low intermediate.
16. Chateaugay [5]	June 28	Do.
Bowline Series (July-December)		
17. Tanya	July 30	Low.
18. Diana Moon [4]	Aug. 27	Low.
19. Sled [5]	Aug. 29	Low intermediate.
20. Noggin	Sept. 6	Do.
21. Knife A	Sept. 12	Low.
22. Hudson Seal [4]	Sept. 24	Low.
23. Knife C	Oct. 3	Low.
24. Crew	Nov. 4	Low intermediate.
25. Knife B	Nov. 15	Low.
26. Ming Vase [4]	Nov. 20	Low.
27. Tinderbox	Nov. 22	Low.
28. Tyg	Dec. 12	Low.
29. Benham [5]	Dec. 19	Low megaton.

[1] Plowshare (peaceful uses) program detonations are not included (see ch. 11).

[2] Low yield, less than 20 kt. (kiloton); low intermediate yield, 20 to 200 kt.; intermediate yield, 200 kt. to 1 mt.; and low megaton yield, 1 to several megatons.

[3] Central Nevada calibration test at Hot Creek Valley, Nev., supplemental test area.

[4] DOD test conducted with AEC laboratory assistance.

[5] Conducted in the Pahute Mesa area of the NTS.

[6] Joint AEC-DOD Vela detection experiment.

APPENDIX 5

RULES AND REGULATIONS

The AEC's regulations are contained in title 10, chapter I of the Code of Federal Regulations. Effective and proposed regulations concerning licensed activities and published in the *Federal Register* during 1968 are set forth below.

REGULATIONS AND AMENDMENTS PUT INTO EFFECT

Implementation of Second Regulatory Review Panel Recommendations—Parts 2, 50, and 115

On June 12, 1968, 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 July 12, 1968, which reflected in part the recommendations made by the Second Regulatory Review Panel. Among other changes, Part 2 was amended to clarify the rules pertaining to intervention and to permit the appointment of alternates to atomic safety and licensing boards who are qualified to conduct administrative proceedings.

Availability of Records—Part 9

On September 27, 1968, an amendment to Part 9—Public Records, was published, effective October 27, 1968. The amendments clarified certain provisions of Part 9, provided access to more Commission records at major field offices, and made certain records of the Commission available at contractors' and subcontractors' facilities.

Filing of Documents—Part 2

On May 2, 1968, amendments of Part 2 ("Rules of Practice") were published, effective on publication, directing that certain documents relating to adjudications and petitions for rule making be filed by delivery to the AEC Public Document Room at 1717 H Street, N.W., Washington, D.C., or by mail or telegram addressed to the Secretary of the Commission, Attention, Public Proceedings Branch, as appropriate.

Reporting Requirements—Part 20

On December 19, 1968, amendments to Part 20 ("Standards for Protection Against Radiation") were published, to become effective February 17, 1969, which require four categories of licensees to report to the Commission certain information on radation exposures to monitored individuals. The reporting requirements apply only to: (*a*) operators of nuclear power reactors and testing facilities; (*b*) industrial radiographers: (*c*) fuel processors, fabricators, or reprocessors who possess more than 5,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof; and (*d*) persons who possess specified quantities of byproduct material for purposes of processing or manufacturing for distribution pursuant to Parts 30, 32, or 33. An annual report will be required setting forth the total number of individuals for whom personnel monitoring was required or provided during the year, and individual exposure information for those individuals who received an annual external dose in excess of the quarterly numerical values specified in § 20.101(a) (*e.g.,* 1.25 rems whole body exposure). A report of each individual's exposure to radiation and radioactive material incurred during the period of employment or work assignment in a licensee's facility, as presently required to be recorded under Part 20, is to be submitted to the Commission, with a copy to the individual concerned, within 30 days after termination of the individual's employment or work assignment.

License Fees—Parts 30, 40, 50, 70, and 170

A new Part 170 ("License Fees for Facility Licenses and Materials Licenses"), and appropriate amendments to Parts 30 ("Rules of General Applicability to Licensing of Byproduct Material"), 40 ("Licensing of Source Material"), 50, and 70 ("Special Nuclear Material") were published on August 1, 1968, effective October 1, 1968. The new Part 170 establishes fees for facility construction permits and operating licenses and for certain specific byproduct, source, and special nuclear materials licenses.

Under the established schedule, fees will be charged for licenses to construct and to operate nuclear reactors and other production or utilization facilities; for licenses for byproduct material of 100,000 curies or more in sealed sources used for irradiation of materials; for licenses for special nuclear material in quantities sufficient to form a critical mass (except plutonium-beryllium neutron sources); and for waste disposal licenses specifically authorizing the receipt of waste materials from other persons for the purpose of commercial disposal by the waste disposal licensee.

Promethium-147 in Self-Luminous Aircraft Safety Devices—Parts 31, 32

On April 27, 1968, amendments of Parts 31 ("General Licenses for Certain Quantities of Byproduct Material and Byproduct Material Contained in Certain Items") and 32 ("Specific Licenses to Manufacture, Distribute or Import Exempted and Generally Licensed Items Containing Byproduct Material") were published, effective May 27, 1968, which increased the quantity limit of generally licensed promethium-147 in any single aircraft safety device from 100 to 300 millicuries.

General License for Iodine-125 and Iodine-131 for In Vitro Tests—Parts 31, 32

On November 14, 1968, amendments of Parts 31 and 32 were published, effective January 13. The amendment of Part 31 provides a new general license to physicians, clinical laboratories, or hospitals for the possession and use of specified quantities of iodine-125 or iodine-131 for *in vitro* clinical or laboratory tests. The amendment of Part 32 includes requirements for issuance of specific licenses to distribute iodine-125 or iodine-131 for use under the general license.

Labeling Requirements For Luminous Aircraft Safety Devices—Part 32

On November 7, 1968, amendments of the labeling requirements for luminous aircraft safety devices generally licensed under § 31.7 were published, effective December 7, 1968.

Specific Licenses of Broad Scope for Byproduct Material—Part 33

On September 28, 1968, a revision of Part 33 ("Specific Licenses of Broad Scope for Byproduct Material") was published, effective October 28, 1968, to permit the wider use of broad licenses by providing three types of broad licenses. A "Type A" broad license is essentially the same as the broad license in the previous Part 33. "Type B" and "Type C" broad licenses were added to provide similar flexibility for specially qualified applicants with intermediate or small-scale radioisotope programs.

General License to Export Uranium—Part 40

On August 22, 1968, an amendment to Part 40 was published, effective upon publication, to permit export under general license of uranium when fabricated as shielding and contained in radiographic exposure or teletherapy devices in quantities not to exceed 500 pounds per device to countries other than Sino-Soviet destinations and Southern Rhodesia. A general license was also provided authorizing the export of uranium in the devices to Southern Rhodesia if the devices are for use in medical diagnosis or therapy.

Pile Driving Before Issuance of Construction Permit—Parts 50, 115

On January 31, 1968, amendments to Parts 50 and 115 were published, effective March 1, 1968, which permit the driving of piles for foundation support of a nuclear reactor in advance of the issuance of a construction permit.

Financial Qualifications of Applicants for Nuclear Facility Licenses—Part 50

On July 4, 1968, an amendment of Part 50 was published, effective September 2, 1968, to provide additional guidance on the general kinds of information that normally will be required to establish financial qualifications of applicants for licenses to construct and operate nuclear reactors and other production and utilization facilities.

Technical Specifications and Safety Analysis Reports—Part 50

On December 17, 1968, amendments to Part 50 were published, effective on January 16, 1969, which: (*a*) established a revised system of technical specifications, (*b*) provided for systematic documentation of the bases for such specifications, and (*c*) provided further guidance as to content of preliminary and final safety analysis reports required of applicants for nuclear facility construction permits and operating licenses.

Communications Concerning SNM—Part 70

On January 5, 1968, an amendment to Part 70 was published, effective that day, directing that communications with the Commission concerning solely the safeguarding of licensed special nuclear material, be addressed to the Division of Nuclear Materials Safeguards.

General License for Ownership of Special Nuclear Material—Part 70

On July 9, 1968, an amendment of Part 70 was published, effective August 8, 1968, which provides a general license for ownership of special nuclear material. The general license includes the right both to receive and transfer ownership of special nuclear material.

Extension of SNM Reporting Requirements—Part 70 and Part 150

On June 27, 1968, amendments of Part 70 and Part 150 ("Exemption and Continued Regulatory Authority in Agreement States under Section 274") were published in the *Federal Register,* effective July 27, 1968, which require AEC licensees to submit to the Commission on prescribed AEC forms, transfer and semiannual status reports on all privately owned special nuclear material regardless of origin. Also, persons who are Agreement State licensees are required to submit transfer reports on AEC-leased and privately owned material. Previously, such reports were required only from AEC licenses for special nuclear material distributed under Section 53 of the Atomic Energy Act.

Packaging of Radioactive Material for Transport—Part 71

On November 26, 1968, amendments to Part 71 ("Packaging of Radioactive Material for Transport") were published, effective on December 31, 1968, to conform AEC regulations on packaging of radioactive material for transport to the recent revision of Department of Transportation regulations pertaining to safety in the transport of radioactive material.

Criteria for Determination of an Extraordinary Nuclear Occurrence—Part 140

An amendment to Part 140 was published on October 31, 1968, effective on November 30, 1968 which establishes the criteria by which the Commission would make a determination of an "extraordinary nuclear occurrence" and incorporates waivers of defenses provisions in nuclear liability insurance policies and in the indemnity agreements with licensees.

Miscellaneous Amendments—Parts 1, 20, 115

On March 30, 1968, amendments of Parts 1 ("Statement of Organization, Delegations, and general Information"), 20 ("Standards for Protection Against Radiation"), and 115 ("Procedures for Review of Certain Nuclear Reactors Exempted from Licensing Requirements") were published, effective on publication, pertaining to corrective and procedural matters and revising addresses and telephone numbers of the Compliance Regional Offices.

PROPOSED REGULATIONS AND AMENDMENTS

Reports of Loss or Theft of Licensed Material—Part 20

On October 23, 1968, proposed amendments to Part 20 were published for public comment which would require licensees to submit a written report concerning losses or thefts of licensed material in addition to the telephonic and telegraphic reports now required by Part 20.

Proposed Exemption of Small Quantities of Byproduct Material—Parts 20, 30, 31, 32, and 35

On August 10, 1968, proposed amendments of Parts 20, 30, 31, 32, and 35 ("Human Uses of Byproduct Material") were published for public comment. The proposed amendments would establish an exemption from licensing requirements for certain small quantities of byproduct material in lieu of the general license for certain small quantities currently set forth in §§ 31.4 and 31.100 of Part 31. The proposed amendment of Part 20 would amend Appendix C to add americium-241, to conform the quantities of byproduct material listed in Appendix C to the proposed exempt quantities and to change certain other quantities listed in Appendix C.

Class Exemption of Gas and Aerosol Detectors—Parts 30 and 32

On November 1, 1968, proposed amendments of Parts 30 and 32 were published for public comment. The proposed amendments to Part 30 would establish a class exemption for byproduct material contained in gas and aerosol detectors, designed to protect life or property from fires and airborne hazards, when such detectors have been manufactured, imported or transferred under a specific license issued by the Commission authorizing distribution for use under the exemption. The changes to Part 32 would establish requirements for issuance of specific licenses to manufacture, import, or transfer detectors for use under the exemption.

Exemption of Electron Tubes Containing Byproduct Material—Parts 30, 31, and 32

On November 14, 1968, proposed amendments of Parts 30, 31, and 32 were published for public comment. The proposed amendments to Part 30 would exempt from licensing requirements electron tubes containing not more than 10 millicuries of tritium, or 1 microcurie of cobalt-60, or 5 microcuries of nickel-63 or cesium-137, or 30 microcuries of krypton-85. Changes to Part 32 would except electron tubes from visual inspection requirements. The general license for certain quantities of byproduct material in spark gap and electron tubes would be revoked.

Proposed Exemption of Tritium, Krypton-85, and Promethium-147 in Self-Luminous Products—Parts 30, 32

On June 21, 1968, proposed amendments of Parts 30 and 32 were published for public comment. The proposed amendments to Part 30 would establish a class exemption for self-luminous products containing tritium, krypton-85, and promethium-147 when such products have been manufactured, imported, or transferred under a specific license issued by the Commission authorizing distribution for use under the exemption. Proposed changes to Part 32 would establish requirements for issuance of specific licenses to manufacture, import, or transfer luminous products for use under the class exemption.

Transfer of Products Containing Agreement Materials—Part 150

On February 24, 1968, a proposed amendment of Part 150 ("Exemptions and Continued Regulatory Authority in Agreement States under Section 274") was published for public comment which would redefine the basis of continued AEC regulatory authority in Agreement States over the transfer by the manufacturer of products containing byproduct or source material whose subsequent possession, use, transfer, and disposal are exempted from Commission licensing and regulatory requirements.

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 27, 1962	July 26, 1969
Australia	do	May 28, 1957	May 27, 1997
Austria	Research	Jan. 25, 1960	Jan. 24, 1970
Brazil	do	Nov. 9, 1966	Aug. 2, 1975
Canada	Research and Power	July 21, 1955	July 13, 1980
China, Republic of	Research	Ju.y 18, 1955	July 17, 1974
Colombia [1]	do	Mar. 29, 1963	Mar. 28, 1967
Denmark	do	July 25, 1955	July 24, 1973
Greece	do	Aug. 4, 1955	Aug. 3, 1974
India	Research and Power	Oct. 25, 1963	Oct. 24, 1993
Indonesia	Research	Sept. 21, 1960	Sept. 20, 1970
Iran	do	Apr. 27, 1959	Apr. 26, 1969
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 21, 1955	July 20, 1969
South Africa	Research and Power	Aug. 22, 1957	Aug. 21, 1977
Spain	do	Feb. 12, 1958	Feb. 11, 1988
Sweden	do	Sept. 15, 1966	Sept. 14, 1996
Switzerland	do	Aug. 8, 1966	Aug. 7, 1996
Thailand	Research	Mar. 13, 1956	Mar. 12, 1975
Turkey	do	June 10, 1955	June 9, 1971
United Kingdom	do	July 21, 1955	July 20, 1976
United Kingdom	Power	July 15, 1966	July 14, 1976
Venezuela	Research and Power	Feb. 9, 1960	Feb. 8, 1970
Vietnam	Research	July 1, 1959	June 30, 1974
Special arrangement:			
U.S.-U.S.S.R	Agreement on Cooperation in Desalination (Information and Personnel Exchange).	Nov. 18, 1964	Nov. 18, 1968
U.S.-U.S.S.R	Memorandum on Cooperation on the Peaceful Uses of Atomic Energy.	July 29, 1968	Dec. 31, 1969
U.S.-Romania	do	Jan. 1, 1969	Dec. 31, 1970

See footnotes at end of tables.

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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

Participant	Scope	Effective Date
U.S./IAEA/Argentina	Trilateral for application of IAEA safeguards to U.S.-supplied materials.	Mar. 1, 1966
U.S./IAEA/Australia	do	Sept. 26, 1966
U.S./IAEA/Austria	do	Dec. 13, 1965
U.S./IAEA/Brazil	do	Oct. 31, 1968
U.S./IAEA/Republic of China	do	Oct. 29, 1965
U.S./IAEA/Denmark	do	Feb. 29, 1968
U.S./IAEA/Greece	do	Jan. 13, 1966
U.S./IAEA/Indonesia	do	Dec. 6, 1967
U.S./IAEA/Israel	do	June 15, 1966
U.S./IAEA/Iran	do	Dec. 4, 1967
U.S./IAEA/Japan	do	July 10, 1968
U.S./IAEA/Korea	do	Jan. 5, 1968
U.S./IAEA/Philippines	do	July 15, 1968
U.S./IAEA/Portugal	do	Dec. 15, 1965
U.S./IAEA/South Africa	do	July 26, 1967
U.S./IAEA/Spain	do	Dec. 9, 1966
U.S./IAEA/Thailand	do	Sept. 10, 1965
U.S./IAEA/Venezuela	do	Mar. 27, 1968
U.S./IAEA/Vietnam	do	Oct. 25, 1965
U.S./IAEA/Turkey	do	(2)

Agreements for Cooperation for Mutual Defense Purposes [3]

Participant	Effective Date
NATO	Mar. 12, 1955
Australia	Aug. 14, 1957
Belgium	Sept. 5, 1962
Canada	July 27, 1959
France (Land-Based Prototype Fuel Supply Agreement)	July 20, 1959
France	Oct. 9, 1961
Germany, Federal Republic of	July 27, 1959
Greece	Aug. 11, 1959
Italy	May 24, 1961
Netherlands	July 27, 1959
Turkey	July 27, 1959
United Kingdom [4]	Aug. 4, 1958

[1] Extending agreement signed but not yet in force.

[2] Effective date to be established.

[3] Except for the Agreement with France of July 20, 1959, all these Agreements provide for exchange of classified information as provided for in Sec. 144b of the Atomic Energy Act.

[4] The United Kingdom agreement is the only one that also provides for the exchange of weapon design information or exchange of nuclear materials for use in a weapon development and fabrication program.

APPENDIX 7

TECHNICAL INFORMATION

Table 1.—SPECIALIZED INFORMATION AND DATA CENTERS SPONSORED BY AEC [1]

Name of center	Location	Address
Accelerator Information Center	Oak Ridge National Laboratory.	Post Office Box X, Oak Ridge, Tenn. 37830.
Aerospace Radioisotope Information Center.[2]	Sandia Laboratory	Post Office Box 5800, Albuquerque, N. Mex. 87115.
Argonne Code Center	Argonne National Laboratory	9700 South Cass Ave., Argonne, Ill. 60440.
Atomic and Molecular Processes Information Center.	Oak Ridge National Laboratory.	Post Office Box Y, Oak Ridge, Tenn. 37830.
Charged Particle Cross Section Information Center.	do	Post Office Box X, Oak Ridge, Tenn. 37830.
Computer Index Neutron Data Center.	Div. of Technical Information Extension	Post Office Box 62, Oak Ridge, Tenn. 37830.
Criticality Data Center	Oak Ridge National Laboratory.	Post Office Box Y, Oak Ridge, Tenn.
Fused Salts Information Center	Sandia Laboratory	Post Office Box 5800, Albuquerque, N. Mex. 87115.
Gamma Ray Spectrum Catalog	National Reactor Testing Station.	Post Office Box 1845, Idaho Falls, Idaho 83401.
Information Center for Internal Exposure.	Oak Ridge National Laboratory.	Post Office Box X, Oak Ridge, Tenn.
Information Integration Group	Lawrence Radiation Laboratory.	Post Office Box 808, Livermore, Calif. 94550.
Isotopes Information Center	Oak Ridge National Laboratory.	Post Office Box X, Oak Ridge, Tenn. 37830.
Liquid Metals Information Center	Atomics International	Post Office Box 1449, Canoga Park, Calif. 91304.
National Neutron Cross Section Data Center.[4]	Brookhaven National Laboratory.	Upton, N.Y. 11973.
National Oceanographic Data Center.	U.S. Naval Oceanographic Office.	Washington, D.C. 20390.
Nuclear Constants Group [3]	Lawrence Radiation Laboratory.	Post Office Box 808, Livermore, Calif. 94550.
Nuclear Data Project	Oak Ridge National Laboratory.	Post Office Box X, Oak Ridge, Tenn. 37830.
Nuclear Desalination Information Center.	do	Post Office Box Y, Oak Ridge, Tenn. 37830.
Nuclear Safety Information Center	do	Do.
Particle Data Center	Lawrence Radiation Laboratory.	University of California, Berkeley, Calif. 94720.
Radiation Chemistry Data Center	Radiation Laboratory	University of Notre Dame, Notre Dame, Ind. 46556.
Radiation Shielding Information Center.	Oak Ridge National Laboratory.	Post Office Box X, Oak Ridge, Tenn. 37830.
Reactor Physics Constants Center	Argonne National Laboratory	9700 South Cass Ave., Argonne, Ill. 60439.

See *footnotes at end of table.*

Table 1.—SPECIALIZED INFORMATION AND DATA CENTERS SPONSORED BY AEC [1]—Con.

Name of center	Location	Address
Research Materials Information Center.	Oak Ridge National Laboratory.	Post Office Box X, Oak Ridge, Tenn. 37830.
Shock Wave Data Center	Lawrence Radiation Laboratory.	Post Office Box 808, Livermore, Calif. 94550.
Simulated Environment Information Center.	Sandia Laboratory	Post Office Box 5800, Albuquerque, N. Mex. 87115.
Thermodynamic Properties of Metals and Alloys.	Lawrence Radiation Laboratory.	University of California, Berkeley, Calif. 94720.

[1] Further detail as to the subject scope covered and services provided by each center and the users for whom services are available is provided in a "Directory of U.S. AEC Specialized Information and Data Centers," available free from the U.S. AEC, Post Office Box 62, Oak Ridge, Tenn. 37830.
[2] Name changed from Aerospace Nuclear Safety Information Center.
[3] Name changed from Scientific Information Systems Group.
[4] Name changed from Sigma Center.

Table 2.—AEC-SPONSORED BOOKS, MONOGRAPHS, AND PROCEEDINGS PUBLISHED IN 1968

Title	Authors and editors	Publisher and price
Books		
Late Somatic Effects of Ionizing Radiation.	C. D. Van Cleave	$3.00.[1]
Radiation Biology	A. P. Casarett	Prentice-Hall, Inc. Englewood Cliffs, N. J., $9.25.
Meteorology and Atomic Energy 1968	D. H. Slade	$3.00.[1]
Radioisotopes and Inquiry, Student and Teacher Editions.	Bio-Atomic Research Foundation.	Encyclopedia Britannica, Chicago, Ill., $2.50.
Critical Review Series		
Reactor-Noise Analysis in the Time Domain.	N. Pacilio	$3.00.[1]
Sources of Tritium and Its Behavior Upon Release to the Environment.	D. G. Jacobs	$3.00.[1]
Monographs (Cooperating Society)		
Radioisotopes in the Human Body (American Institute of Biological Sciences).	F. W. Spiers	Academic Press New York City, $15.00.
Fabrication of Thorium Fuel Elements (American Society for Metals).	L. R. Weissert, G. Schileo	American Nuclear Society, Hinsdale, Ill., $11.10.
AEC Symposium Series		
Radioisotopes in Medicine: In Vitro Studies.	R. Hayes, F. Goswitz, F. B. Anderson.	$3.00.[1]

[1] Available at the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.

Table 3.—BOOKLETS IN AEC'S "UNDERSTANDING THE ATOM" SERIES [1]

Accelerators
Animals in Atomic Research
Atomic Fuel
Atomic Power Safety
Atoms at the Science Fair
Atoms in Agriculture
Atoms, Nature and Man
Careers in Atomic Energy
Computers
Controlled Nuclear Fusion
Cryogenics, The Uncommon Cold
Direct Conversion of Energy
Fallout From Nuclear Tests
Food Preservation by Irradiation
Genetic Effects of Radiation
Index to the Understanding the Atom Series
Lasers
Microstructure of Matter
Neutron Activation Analysis

[1] See footnote at end of table.

Table 3.—BOOKLETS IN AEC'S "UNDERSTANDING THE ATOM" SERIES [1]—Continued

Nondestructive Testing
Nuclear Clocks
Nuclear Energy for Desalting
Nuclear Power and Merchant Shipping
Nuclear Power Plants
Nuclear Propulsion for Space
Nuclear Reactors
Nuclear Terms, A Brief Glossary
Our Atomic World
Plowshare
Plutonium
Power From Radioisotopes
Power Reactors in Small Packages
Radioactive Wastes
Radioisotopes and Life Processes
Radioisotopes in Industry
Radioisotopes in Medicine
Rare Earths
Reading, Resources in Atomic Energy
Research Reactors
SNAP, Nuclear Space Reactors
Sources of Nuclear Fuel
Space Radiation
Spectroscopy
Synthetic Transuranium Elements
The Atom and the Ocean
The Chemistry of the Noble Gases
The First Reactor
The Natural Radiation Environment
Whole Body Counters
Your Body and Radiation

[1] Single copies (limit: three titles per request) are available free from the U.S. AEC-Technical Information, Post Office Box 62, Oak Ridge, Tenn. 37830.

Table 4.—AEC/NASA TECHNOLOGY SURVEYS [1]

Teleoperators and Human Augmentation (NASA–SP–5047)
Machining and Grinding of Ultrahigh Strength Steel and Stainless Steels (NASA–SP–5084)
Adhesive Bonding of Stainless Steels—Including Precipitation-Hardening Stainless Steels (NASA–SP–5085)
Shaping of Precipitation-Hardening Stainless Steels by Casting and Powdered Metallurgy (NASA–SP–5086)
Welding of Precipitation-Hardening Stainless Steels (NASA–SP–5087)
Deformation Processing of Precipitation-Hardening Stainless Steels (NASA–SP–5088)
Thermal and Mechanical Treatment of Precipitation-Hardening Stainless Steels (NASA–SP–5089)
Surface Treatments of Precipitation-Hardening Stainless Steels (NASA–SP–5090)

[1] Available, for $3 each, from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.

Table 5.—LIST OF STATE ORGANIZATIONS COOPERATING IN "THIS ATOMIC WORLD" HIGH SCHOOL LECTURE-DEMONSTRATION PROGRAM

State	Participating organization	First year in program
Texas	Texas A&M University	1966
North Carolina	N.C. State University	1967
New York (2 units)	Empire State Atomic Developments Associates	1967
Oklahoma	Oklahoma State University	1968
Oregon	University of Oregon	1968
Kentucky	Morehead State University	1968
Florida	University of South Florida	1968
Wisconsin	University of Wisconsin	1968
Louisiana	Louisiana Board of Nuclear Energy (operated by Louisiana State University).	1968

APPENDIX 8

AEC FINANCIAL SUMMARY FOR FISCAL YEAR 1968*

The Atomic Energy Commission is an independent agency responsible to the President and Congress. It was established by the Atomic Energy Act of 1946 to assume the responsibility for the development, use and control of atomic energy and for the production of nuclear weapons. In 1954 the functions and responsibilities of the AEC were expanded to provide for greater emphasis on developing and promoting peaceful uses of atomic energy. In 1964 the law was changed to promote private ownership of special nuclear material. The Private Ownership of Special Nuclear Materials Act of 1964 authorized the AEC to offer a service of enriching privately owned uranium in uranium-235 under long-term contracts. The AEC will begin this service January 1, 1969 and expects this method of acquiring enriched uranium to be used extensively.

The AEC's operating expenses are approximately $2.5 billion per year. Most of the work involved in achieving the AEC goals is performed under contract with AEC by commercial firms and educational and other nonprofit organizations in government-owned facilities. These AEC contractors have approximately 112,000 employees engaged in operations and 10,000 in construction work. The AEC has about 7,700 employees.

The AEC is a decentralized organization with offices located in various parts of the country. The employees at these offices have been delegated the responsibility for administering the major production and research and development contracts. The field offices account for 4,600 of the total AEC employment.

Those responsible for management require knowledge of the costs incurred within the AEC complex. The AEC accounting system must not only supply such knowledge but must comply with the requirements of Federal Government fund accounting. The system developed to meet both these requirements has the approval of the General Accounting Office. Like industrial accounting systems it follows accrual and cost accounting principles, including the recording of depreciation. The accounting records maintained by major contractors for their AEC activities are an integral part of the AEC's system of financial management.

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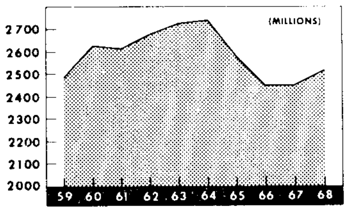
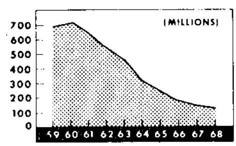
*Material in this appendix is extracted from the "U.S. Atomic Energy Commission—1968 Financial Report," available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, price 65 cents.

SUMMARY OF NET OPERATING COSTS

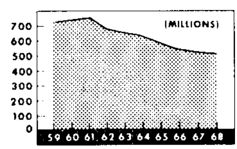
1968
(Millions)



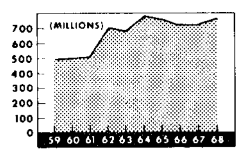
TOTAL OPERATING COSTS.......... $2507 100%



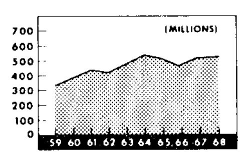
PROCUREMENT OF RAW MATERIALS......... $125 5%



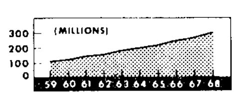
PRODUCTION OF NUCLEAR MATERIALS..... $507 20%



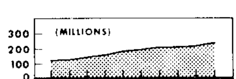
WEAPONS DEVELOPMENT AND FABRICATION...... $784 31%



REACTOR DEVELOPMENT.... $549 22%



PHYSICAL RESEARCH...... $310 13%



OTHER PROGRAMS........ $232 9%

STATEMENT OF OPERATIONS

	Fiscal Year 1968	1967
	(in thousands)	
Production		
Procurement of raw materials	$125,377	*$162,000*
Production of nuclear materials	506,911	*521,316*
Weapons development and fabrication	783,581	*736,593*
Total	1,415,869	*1,419,909*
Research and development		
Development of nuclear reactors	548,546	*528,028*
Physical research	310,140	*291,911*
Biology and medicine research	98,601	*95,208*
Plowshare	20,029	*14,730*
Isotope development	8,370	*7,667*
Total	985,686	*937,544*
Community operations		
Expenses	1,952	*5,038*
Revenues	(1,032)	*(3,288)*
Total	920	*1,750*
Sales of materials and services		
Cost	61,093	*65,124*
Revenue	(65,926)	*(77,270)*
Total	(4,833)	*(12,146)*
Education and training	9,766	*10,008*
AEC administrative expenses	96,984	*89,492*
Security investigations	6,848	*6,250*
Other expenses	13,233	*13,019*
Other income	(17,620)	*(19,302)*
Net cost of operations[1]	2,506,853	*2,446,524*
Special items		
Adjustments to costs of prior years—net	75,337	*32,026*
Transfers to inventories—net	(266,295)	*(112,629)*
Net cost of operations—after special items[1]	$2,315,895	*$2,365,921*

[1] Includes depreciation of $361 million in 1968 and $350 million in 1967.

BALANCE SHEET

ASSETS*	June 30, 1968 (*in thousands*)	June 30, 1967 (*in thousands*)
Cash		
Funds in U.S. Treasury	$1,499,723	$1,457,187
Cash on hand and with contractors	7,006	2,592
Transfers from other agencies	1,437	5,166
Total	1,508,166	1,464,945
Accounts receivable		
Federal agencies	50,714	42,515
Other	61,314	56,140
Total	112,028	98,655
Inventories		
Source and nuclear materials leased and at research installations	1,058,573	869,723
Special reactor materials	101,786	91,283
Stores	89,795	89,796
Isotopes	39,080	42,744
Other special materials	14,457	14,575
Total	1,303,691	1,108,121

LIABILITIES AND AEC EQUITY*	June 30, 1968 (*in thousands*)	June 30, 1967 (*in thousands*)
Liabilities		
Accounts payable and accrued expenses	$313,338	$334,939
Advances from other agencies	1,437	11,288
Funds held for others	15,026	14,977
Accrued annual leave of AEC employees	10,311	10,016
Deferred credits	15,043	10,961
Total liabilities	355,155	382,181
AEC equity, July 1	8,065,706	8,286,916
Additions		
Funds appropriated—net	2,509,125	2,198,864
Non-reimbursable transfers from other agencies	3,598	6,558
	2,512,723	2,205,422
Deductions		
Net cost of operations—after special items	2,315,895	2,365,921
Non-reimbursable transfers to other agencies	71,406	60,708
Funds returned to U.S. Treasury	955	3
	2,388,256	2,426,632

Plant		
Completed plant and equipment	8,826,896	8,819,749
Less—accumulated depreciation	3,595,128	3,353,727
	5,231,768	5,466,022
Construction work in progress	299,948	242,583
Total	5,531,716	5,708,605
Other	89,727	67,561
Total assets	8,545,328	8,447,887

AEC equity, June 30	8,190,173	8,065,706
Total liabilities and AEC equity	8,545,328	8,447,887

*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. 50,772,284 troy ounces of silver loaned to the AEC by the Treasurer of the United States for use as electrical conductors in plants. Of this amount, 280,500 troy ounces have been lost in usage and are, therefore, not returnable. Based on Treasury selling price at June 30, 1968, the value of the silver on loan was $126,422,988. The value of silver lost and the cost of recovering and processing that on hand and returning it to the Treasury is estimated at $1,090,000.
   c. Plant and equipment on loan from other Federal Agencies at June 30, 1968, amounting to $39,216,000.
   d. Contested claims against others of $2,379,000.
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, 1968, the estimated liabilities would have amounted to $386,600,000.
   b. Contingent liabilities for claims against the AEC of $27,643,000.
   c. Commitments for an estimated 19,818 tons of U_3O_8 at an estimated cost of $248,284,000.
   d. Commitments under section 56 of the Atomic Energy Act of 1954, as amended, for acquisition of plutonium and uranium enriched in the isotope 233. Estimated commitments of $1,900,000 for fiscal year 1969 are based upon projected quantities of plutonium and uranium enriched in the isotope 233 to be produced by domestic licensees and delivered to the AEC during this period. There is also additional liability, difficult to estimate accurately at this time, for purchase under section 56 of additional quantities of reactor-produced plutonium and uranium enriched in the isotope 233 which may be delivered to the AEC in future years but prior to January 1, 1971.
   e. Outstanding contracts, purchase orders and other commitments of $1,197,000,000.

COSTS INCURRED BY RESEARCH LABORATORIES

A major portion of AEC research and development is conducted in Government-owned laboratories operated by educational institutions and industrial concerns under AEC contracts. On June 30, 1968, the AEC's investment in research facilities totaled $2.9 billion. Of this amount, $2.0 billion was invested in the major Government-owned laboratories. These facilities include research reactors, particle accelerators, general laboratory buildings, equipment, and research devices. Research and development work conducted in AEC laboratories includes central station nuclear power design and development, research in the physical and life sciences, nuclear weapons development, research on peaceful applications for nuclear explosives and research to improve nuclear materials processes and techniques.

The 10 laboratories listed are the principal AEC-owned research centers. The operating costs of these laboratories together with the costs incurred at other AEC-owned installations and the cost of the work performed in facilities owned by universities, industrial, and other privately owned organizations are included in the costs of the various research areas shown throughout this report.

The basic research carried out in the AEC laboratories, while motivated and justified on the basis of its relevance to atomic energy, is not limited to atomic energy purposes in its eventual usefulness and application. As in the past, the basic knowledge arising from AEC programs will continue to make contributions to non-AEC programs of great national significance.

Within present authorities, a portion of AEC laboratory capabilities is being used on problems of other agencies, giving due regard to the AEC mission and the interface it has with the interests of other agencies.

Laboratories	Cost of completed plant June 30, 1968	Operating costs fiscal year	
		1968	1967
	[In thousands]		
Ames Research Laboratory	$22,461	$9,363	$9,036
Argonne National Laboratory [1]	339,248	102,030	87,360
Bettis Atomic Power Laboratory [1]	137,606	73,627	63,045
Brookhaven National Laboratory	229,005	63,103	60,894
Knolls Atomic Power Laboratory [1]	148,484	65,376	52,722
Lawrence Radiation Laboratory [2]	319,025	184,031	167,090
Los Alamos Scientific Laboratory [2]	266,884	104,620	106,216
Oak Ridge National Laboratory	335,121	90,350	92,263
Pacific Northwest Laboratory	105,146	50,951	42,803
Savannah River Laboratory	72,089	13,567	13,144

[1] Includes facilities at NRTS, Idaho.
[2] Includes facilities in Nevada.

AEC COSTS INCURRED BY GEOGRAPHICAL LOCATIONS

The table on this page shows the costs incurred by the AEC in fiscal year 1968. Allocations of costs are made in accordance with the physical location of contractors and AEC offices but do not necessarily represent funds spent in those locations.

Location	Operations*	Plant and capital equipment	Total
		[In thousands]	
Alabama	$90		$90
Alaska	39,644		39,644
Arizona	732		732
Arkansas	124		124
California	295,825	$45,857	341,682
Colorado	50,325	19,763	70,088
Connecticut	6,457	359	6,816

Location	Operations*	Plant and capital equipment	Total
		[In thousands]	
Delaware	$19		$19
District of Columbia	14,182	$1,835	16,017
Florida	16,911	3,894	20,805
Georgia	1,261	24	1,285
Hawaii (including Pacific Test Area)	3,354	8	3,362
Idaho	67,484	20,384	87,868
Illinois	94,244	37,297	131,541
Indiana	2,905	679	3,584
Iowa	17,442	3,271	20,713
Kansas	627	271	898
Kentucky	54,144	687	54,831
Louisiana	190		190
Maine	188		188
Maryland	56,335	1,885	58,220
Massachusetts	24,026	5,939	29,965
Michigan	6,460	515	6,975
Minnesota	6,000	1,573	7,573
Mississippi	57		57
Missouri	71,854	3,679	75,533
Montana	68		68
Nebraska	2,897		2,897
Nevada	165,624	13,118	178,742
New Hampshire	144		144
New Jersey	17,217	2,437	19,654
New Mexico	336,559	34,397	370,956
New York	135,047	29,839	164,886
North Carolina	1,856	654	2,510
North Dakota	54		54
Ohio	99,063	8,090	107,153
Oklahoma	226		226
Oregon	1,389	98	1,487
Pennsylvania	99,204	7,886	107,090
Puerto Rico	4,774	362	5,136
Rhode Island	989		989
South Carolina	77,936	15,075	93,011
South Dakota	358		358
Tennessee	207,117	42,815	249,932
Texas	15,108	3,690	18,798
Utah	13,622	117	13,739
Vermont	46		46
Virginia	3,077	180	3,257
Washington	133,914	14,244	148,158
West Virginia	134		134
Wisconsin	4,806	293	5,099
Wyoming	26,060		26,060
Foreign Countries	6,009	136	6,145
Total	2,184,178	321,351	2,505,529

*Excludes depreciation.

AEC COSTS INCURRED BY COLLEGES AND UNIVERSITIES

In addition to the activities of the AEC laboratories (shown on p. 318), some of which are operated for the AEC by universities or associations of universities, the AEC had other contracts with 229 colleges or universities for atomic energy work. The following table shows that the cost of this work totaled about $164 million in fiscal year 1968 and identifies each university where costs in excess of $500,000 were incurred.

Colleges and universities	Fiscal year 1968	
	Rank by dollar volume of costs incurred	Total costs* (in thousands)
Brown University	37	$768
California Institute of Technology	11	3,547
California, University of	4	9,146
California, University of, at Los Angeles	14	2,709
Carnegie-Mellon University	20	2,074
Case Western Reserve University	28	1,320
Chicago, University of	6	5,330
Colorado, University of	34	982
Columbia University	7	5,256
Cornell University	25	1,604
Duke University	27	1,544
Florida State University	29	1,228
Harvard University	5	6,792
Hawaii, University of	40	595
Illinois, University of	9	4,739
Johns Hopkins University	33	1,068
Kansas, University of	38	624
Maryland, Unversity of	12	3,263
Massachusetts Institute of Technology	3	9,617
Michigan State University	19	2,330
Michigan, University of	15	2,493
Minnesota, Univesity of	21	2,042
New York University	22	1,867
Notre Dame, University of	24	1,663
Ohio State University	42	559
Oregon State University	39	603
Pennsylvania State University	41	582
Pennsylvania, University of	17	2,389
Princeton University	2	16,612
Puerto Rico, University of	18	2,358
Purdue University	23	1,679
Rensselaer Polytechnic Institute	31	1,197
Rice University	35	886
Rochester, University of	8	5,149
Southern California, University of	43	517
Stanford University	1	29,625
Tennessee, University of	26	1,586
Texas A&M University	30	1,221
Texas, University of	36	786
Tufts University	44	514
Utah, University of	32	1,080
Washington, University of	16	2,482
Wisconsin, University of	13	3,244
Yale University	10	3,657
Other (185 colleges and universities)		14,471
Total		163,798

* These costs exclude depreciation and include construction and capital equipment.

AEC COSTS INCURRED BY PRINCIPAL 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 1968, the AEC's principal prime industrial contractors accomplished work amounting to some $1,645 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 (shown on p. 318) are included in the costs of related contractors.

Industrial organizations	Fiscal year 1968: Rank by dollar volume of cost incurred	Fiscal year 1968: Total costs* (in thousands)
ACF Industries, Inc	28	$8,998
Aerojet-General Corp	13	34,825
Anaconda Co	27	12,000
Atlantic Richfield Co	14	32,243
Atlas Corp	26	12,060
Atomics International Division, North American Rockwell Corp	21	21,076
Bendix Corp	7	73,751
Douglas United Nuclear, Inc	9	52,772
Dow Chemical Co	10	40,219
EG&G, Inc	15	30,795
E. I. du Pont de Nemours & Co	4	90,160
Federal-Radorock-Gas Hills Partners	36	5,644
Gulf General Atomic, Inc	16	29,635
General Electric Co	3	103,026
Goodyear Atomic Corp	11	36,873
Holmes & Narver, Inc	8	59,461
Homestake-Sapin Partners	22	17,165
Idaho Nuclear Corp	12	36,476
Kerr-McGee Corp	18	24,182
Martin Marietta Corp	29	8,998
Mason & Hanger-Silas Mason Co	20	22,115
Miller Davis Co	35	5,661
Monsanto Research Corp	17	27,384
National Lead Co	19	23,774
Nuclear Fuel Services, Inc	34	6,024
Pan American World Airways, Inc	24	16,369
Phillips Petroleum Co	25	13,544
Reynolds Electrical and Engineering Co., Inc	5	88,455
Rust Engineering Co	32	8,529
Sandia Corp	2	197,883
Swinerton & Walberg Co	33	8,445
Union Carbide Corp	1	284,044
United Nuclear Corp	23	16,844
Utah Construction & Mining Co	30	8,685
Western Nuclear, Inc	31	8,605
Westinghouse Electric Corp	6	73,793
Other (516 industrial organizations)		104,662
Total		1,645,165

*These costs exclude depreciation and include construction and capital equipment.

AEC PLANT AND EQUIPMENT BY LOCATION

[At cost as of June 30, 1968]

Location and contractor	Authorized plant and equipment (in millions) Completed	Construction work in progress	Estimated cost to complete [1]	Total
CALIFORNIA				
Atomics International Division, North American Rockwell Corp., Canoga Park and Santa Susana Reactor and Research Facilities	$52.6	$0.5	$10.4	$63.5
California Institute of Technology, Pasadena Research Facilities	1.7	1.0	1.0	3.7
University of California, Lawrence Radiation Laboratory				
Berkeley	113.8	3.9	11.4	129.1
Livermore	195.6	17.0	37.7	250.3
Total	309.4	20.9	49.1	379.4
University of California, Davis Bio-Med Research Facilities	4.9	.4	.3	5.6
University of California, Los Angeles Medical Research Facilities	2.1		.5	2.6
EG&G, Inc., Santa Barbara Test Facilities	2.4	.1	.6	3.1
Sandia Corp., Livermore Research Facilities	27.7	.4	2.4	30.5
Stanford University, Palo Alto				
Linear Accelerator	111.7	2.7	2.4	116.8
Other Research Facilities	16.2	7.4	8.8	32.4
Total	127.9	10.1	11.2	149.2
Total California	528.7	33.4	75.5	637.6
COLORADO				
University of Colorado, Boulder	1.5			1.5
Dow Chemical Co., Boulder Rocky Flats Plant	121.7	21.1	56.8	199.6
Lucius Pitkin, Inc., Grand Junction Uranium Handling, Sampling and General Facilities	4.3		.7	5.0
Total Colorado	127.5	21.1	57.5	206.1
CONNECTICUT				
Combustion Engineering, Inc., Windsor Submarine Reactor Facilities	15.2		.1	15.3
Yale University, New Haven Linear Accelerator	10.0		.5	10.5
Total Connecticut	25.2		.6	25.8
FLORIDA				
General Electric Co., Clearwater Pinellas Plant	20.9	3.9	7.3	32.1

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
IDAHO				
National Reactor Testing Station, Idaho Falls				
Argonne National Laboratory				
Reactor Facilities	$42.9	$4.8	$14.3	$62.0
General Electric Co.				
Knolls Atomic Power Laboratory	23.8		.2	24.0
Idaho Nuclear Corp.				
Advanced Test Reactor	41.3	7.0	2.4	50.7
Chemical Processing Plant	63.2	1.1	3.0	67.3
Engineering Test Reactor	14.9			14.9
Experimental Beryllium Oxide Reactor	10.6			10.6
Experimental Organic Cooled Reactor	9.4			9.4
General Facilities	65.3	.6	9.9	75.8
Materials Test Reactor	15.2	.1	.1	15.4
Test Reactor Area	23.4	.2	.3	23.9
Total	243.3	9.0	15.7	268.0
Phillips Petroleum Co.				
Nuclear Safety Test Engineering	11.8	13.2	12.7	37.7
Power Burst Facility	.1	6.0	7.6	13.7
Special Power Excursion Reactor Test	9.4		.5	9.9
Total	21.3	19.2	20.8	61.3
Westinghouse Electric Corp.				
Large Ship Reactor	35.7	.1		35.8
Submarine Thermal Reactor	17.4			17.4
Other Research Facilities	19.3	.5	3.9	23.7
Total	72.4	.6	3.9	76.9
Total Idaho	403.7	33.6	54.9	492.2
ILLINOIS				
University of Chicago, Argonne				
Argonne National Laboratory	296.3	30.9	44.2	371.4
University of Chicago, Chicago				
Argonne Cancer Research Hospital	6.5	.1	.6	7.2
Research Equipment	1.4	.4	.1	1.9
University of Illinois, Urbana				
Research Facilities	2.1		.6	2.7
University Research Association (near Chicago)				
National Accelerator Laboratory		3.0	29.3	32.3
Total Illinois	306.3	34.4	74.8	415.5
INDIANA				
University of Notre Dame, Notre Dame				
Radiation Laboratory	2.9	.1	.4	3.4

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
IOWA				
Ames Research Laboratory, Ames				
Research Facilities	$18.2	$1.0	$2.1	$21.3
Research Reactor	4.3	.5	.1	4.9
Mason and Hanger, Burlington				
AEC Plant	40.3	1.1	6.9	48.3
Total Iowa	62.8	2.6	9.1	74.5
KENTUCKY				
Union Carbide Corp., Paducah				
Feed Materials Plant	31.3			31.3
Gaseous Diffusion Plant	755.4	.4	1.9	757.7
Total Kentucky	786.7	.4	1.9	789.0
MARYLAND				
AEC Headquarters, Germantown	22.2		10.9	33.1
University of Maryland, College Park				
Accelerator	.2	2.4	.4	3.0
Total Maryland	22.4	2.4	11.3	36.1
MASSACHUSETTS				
EG&G, Inc., Boston				
Research Facilities	5.8	.6	2.4	8.8
Harvard University, Cambridge				
Cambridge Accelerator	22.4	.6	3.3	26.3
Massachusetts Institute of Technology, Cambridge				
Research Facilities	7.8	1.1	4.8	13.7
Total Massachusetts	36.0	2.3	10.5	48.8
MICHIGAN				
University of Michigan, Ann Arbor				
Research Facilities	2.1		.1	2.2
Michigan State University, East Lansing				
Research Facilities	1.3		.4	1.7
Total Michigan	3.4		.5	3.9
MINNESOTA				
University of Minnesota, Minneapolis				
Linear Accelerator	5.9		.2	6.1
Rural Cooperative Power Association, Elk River				
Elk River Reactor	10.7		1.3	12.0
Total Minnesota	16.6		1.5	18.1
MISSOURI				
The Bendix Corp., Kansas City				
Kansas City Plant	73.0	3.8	33.4	110.2

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
NEVADA				
Jackass Flats:				
Nuclear Rocket Development Station—Project Rover:				
University of California, Los Alamos Scientific Laboratory	$16.3			$16.3
Pan American World Airways, Inc	63.9	$1.7	$3.5	69.1
Westinghouse Electric Corp	1.7	.2		1.9
Other Research Facilities	2.7			2.7
Total	84.6	1.9	3.5	90.0
Mercury:				
EG&G, Inc.				
Test Facilities	17.2	.3	4.6	22.1
Lawrence Radiation Laboratory				
Laboratory Facilities	9.6		.3	9.9
Reynolds Electrical & Engineering Co.				
Nevada Test Site	135.6	2.6	14.4	152.6
Total	162.4	2.9	19.3	184.6
Sandia Corp., Tonopah				
Research Facilities	11.6		.6	12.2
Total Nevada	258.6	4.8	23.4	286.8
NEW JERSEY				
Atomic Energy Commission, New Brunswick				
New Brunswick Laboratory	3.0	.1	1.0	4.1
Princeton University, Princeton				
Model C Stellarator Facilities	25.5		.3	25.8
Princeton-Pennsylvania Accelerator	36.3	1.0	3.6	40.9
Total New Jersey	64.8	1.1	4.9	70.8
NEW MEXICO				
Albuquerque:				
EG&G, Inc.				
Test Facilities	2.2			2.2
Lovelace Foundation Laboratory	4.4	.1	.6	5.1
Sandia Corp.				
Sandia Laboratory	185.2	4.7	41.1	231.0
Total	191.8	4.8	41.7	238.3
Los Alamos:				
University of California				
Los Alamos Scientific Laboratory	250.7	5.9	89.7	346.3
The Zia Co.				
Community and General Maintenance Facilities	71.8	.1	.8	72.7
Total	322.5	6.0	90.5	419.0
Total New Mexico	514.3	10.8	132.2	657.3

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
NEW YORK				
New York City:				
Atomic Energy Commission				
Health and Safety Laboratory	$2.6		$0.2	$2.3
Columbia University				
Accelerator and Research Facilities	4.4	$0.2	.6	5.2
New York University				
Computing and Other Research Facilities	3.8		.4	4.2
Total	10.8	.2	1.2	12.2
Associated Universities, Inc., Upton				
Brookhaven National Laboratory	229.0	30.8	57.2	317.0
General Electric Co., Schenectady and West Milton				
Knolls Atomic Power Laboratory	124.6	3.2	20.5	148.3
Nuclear Materials and Equipment Corp., Niagara Falls				
Boron Plant	7.4	.1	.6	8.1
Rensselaer Polytechnic Institute, Troy				
Accelerator Facility	2.9		.1	3.0
University of Rochester, Rochester				
Medical Laboratory and 130″ Cyclotron	6.8	.1	.4	7.3
Total New York	381.5	34.4	80.0	495.9
NORTH CAROLINA				
Duke University, Durham				
Accelerator and Research Facilities	1.1	1.7	.8	3.6
OHIO				
Battelle Memorial Institute, Columbus				
Research Facilities	1.0			1.0
General Electric Co., Cincinnati				
Research Facilities	11.2	.1	.6	11.9
Goodyear Atomic Corp., Portsmouth				
Gaseous Diffusion Plant	766.6	.9	2.7	770.2
Monsanto Chemical Co., Miamisburg				
Mound Laboratory	58.3	9.9	23.6	91.8
National Lead Co., Fernald				
Feed Materials Plant	116.9	.7	2.9	120.5
Ohio University, Athens				
Research Facilities			1.0	1.0
Reactive Metals, Inc., Ashtabula				
Feed Materials Facility	1.9		.3	2.2
Total Ohio	955.9	11.6	31.1	998.6

See footnotes at end of table.

AEC PLANT AND EQUIPMENT BY LOCATION—Continued

Location and contractor	Authorized plant and equipment (in millions)			
	Completed	Construction work in progress	Estimated cost to complete [1]	Total
PENNSYLVANIA				
Carnegie-Mellon University, Pittsburgh				
Accelerator and Research Facilities	$1.4			$1.4
Duquesne Light Co., Shippingport				
Shippingport Atomic Power Station	63.4	$0.5	$0.5	64.4
Westinghouse Electric Corp., Large				
Astro Nuclear Laboratory	9.6	.5	3.0	13.1
Westinghouse Electric Corp., Pittsburgh				
Bettis Atomic Power Laboratory	65.1	2.4	17.4	84.9
Total Pennsylvania	139.5	3.4	20.9	163.8
SOUTH CAROLINA				
E. I. du Pont de Nemours & Co., Aiken				
Savannah River Plant				
Feed Materials Production Facility	32.4	.6	1.8	34.8
General Facilities	167.9	2.8	12.2	182.9
Heavy Water Production Facilities	163.0	.2	.1	163.3
Laboratory	72.1	2.3	4.4	78.8
Production Reactor and Separation Facilities	886.3	10.9	14.9	912.1
Total South Carolina	1,321.7	16.8	33.4	1,371.9
TENNESSEE				
Oak Ridge:				
Oak Ridge Associated Universities				
Research Laboratory	5.8	.1	.7	6.6
Rust Engineering Co.				
Service Facilities	10.2	.4		10.6
University of Tennessee				
Agriculture Research Laboratory and Farm	3.6	.1	.3	4.0
Union Carbide Corp.				
Gaseous Diffusion Plant	831.7	1.0	6.8	839.5
Oak Ridge National Laboratory	335.1	16.9	24.4	376.4
Y-12 Plant	388.8	22.6	161.9	573.3
Total Tennessee	1,575.2	41.1	194.1	1,810.4
TEXAS				
Mason and Hanger, Amarillo				
Pantex Plant	54.4	1.7	10.3	66.4
Rice University, Houston				
Research Facility	1.6	.3		1.9
Texas A&M University, College Station				
Research Facilities		3.0	.3	3.3
Total Texas	56.0	5.0	10.6	71.6

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
UTAH				
University of Utah, Salt Lake City	$1.3		$0.1	$1.4
WASHINGTON				
Richland:				
Battelle Memorial Institute				
Pacific Northwest Laboratory	105.2	$4.0	104.1	213.3
Computer Sciences Corp.				
General Facilities	3.9	.1	.2	4.2
Douglas United Nuclear, Inc.				
Feed Materials Production Facilities	24.5	.2	.1	24.8
General Facilities	17.9	.2	4.3	22.4
Production Reactor Facilities	579.3	1.9	4.4	585.6
Total	621.7	2.3	8.8	632.8
Atlantic Richfield Corp.				
General Facilities	2.8		.2	3.0
Separation Facilities	267.1	10.5	9.3	286.9
Total	269.9	10.5	9.5	289.9
ITT/Federal Support Services, Inc.				
General Facilities	67.2	.8	2.1	70.1
J. A. Jones Construction Co.				
General Facilities	2.4			2.4
Total Washington	1,070.3	17.7	124.7	1,212.7
WEST VIRGINIA				
International Nickel Co., Huntington				
Pilot Plant	4.7			4.7
WISCONSIN				
Dairyland Power Cooperative, Genoa				
LaCrosse Boiling Water Reactor	.1	10.2	.5	10.8
University of Wisconsin, Madison				
Research Facilities	1.7			1.7
Total Wisconsin	1.8	10.2	.5	12.5
PUERTO RICO				
University of Puerto Rico, Mayaguez and Rio Piedras				
Puerto Rico Nuclear Center	6.7	.2	2.7	9.6
Puerto Rico Water Resources Authority, Punta Higuera				
Boiling Nuclear Super Heat Reactor	13.5		.9	14.4
Total Puerto Rico	20.2	.2	3.6	24.0
JAPAN				
National Academy of Sciences, Hiroshima				
Research Facilities	2.9	.1	.3	3.3
All other	41.0	3.0	37.7	81.7
Total	8,826.9	299.9	1,037.5	10,164.3

[1] Includes capital equipment.

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