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...57 approved May 13, 1960

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UNITED STATES ATOMIC ENERGY COMMISSION

Annual Report to Congress

OF THE

ATOMIC ENERGY COMMISSION

FOR

1961

January 1962

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

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LETTER OF SUBMITTAL

WASHINGTON, D.C.,
30 January 1962.

SIRS: We have the honor to submit herewith the Annual Report of the United States Atomic Energy Commission for 1961 as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
JOHN S. GRAHAM.
LELAND J. HAWORTH.
LOREN K. OLSON.
ROBERT E. WILSON.
GLENN T. SEABORG, *Chairman.*

Honorable
The President of the Senate.

Honorable
The Speaker of the House of Representatives.

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Field Experiments
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Marine Propulsion
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The President and The Commission. President Kennedy paid a surprise visit to the Atomic Energy Commission's Germantown, Md., headquarters on February 16, 1961. Photo *above* shows the President passing the building's reception desk as he departed after an extended meeting with the Commissioners. Just behind President Kennedy are Commission Chairman Glenn T. Seaborg (center), Commissioner Loren K. Olson, Commissioner Robert E. Wilson (extreme right), and Commission General Manager Alvin R. Luedecke. Photo *below* shows the five members of the Commission, seated left to right: Commissioner Olson, Commissioner John A. Graham, Chairman Seaborg, Commissioner Wilson, and Commissioner Leland J. Haworth.

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THE ATOMIC ENERGY PROGRAM

Progress continued to be made in varied segments of the nation's mic energy program during the calendar year 1961. A number of sts" marked the advances made during the year. The more note-rthy developments included the following:

- The United States was the first nation in the world to send com- nuclear energy power units into space (TRANSIT satellites).
- The first experiment of the Commission's Plowshare Program— ted toward demonstration of peaceful civil benefits achieveable h nuclear explosives—was carried out with success in New Mexico oject Gnome).
- The U.S. Navy commissioned the world's first two nuclear-pro- d fighting surface ships (the cruiser *Long Beach* and the aircraft rier *Enterprise*), and the world's first nuclear merchant ship (NS *nnah*) was fueled and ready to begin sea trials.
- The first large-scale recovery of radioisotopes from fission prod- waste streams was undertaken; and transcontinental shipment of -kilocurie quantities of radioisotopes in a safe and efficient man- as undertaken.
- The world's first radioisotope-powered, unmanned weather sta- began operating from the remote Arctic, and the first atomic- ered navigational buoy was placed in operation in Curtis Bay,
- The first nuclear power plant (Yankee Atomic Power Station) completed under a joint Commission-private industry financial gement surpassed design operating conditions and made en- ging progress toward the ultimate goal of economic nuclear r.
- The Commission received its first formal proposals from two s (Kentucky and California) to assume those regulatory func- prescribed by law as transferable; and another State (New) announced the establishment of a nuclear service center which d include sites for industrial and scientific facilities as well as a ed land-burial site for low-level radioactive wastes.
- Demand for radioisotopes continued to increase as 438,205 curies shipped from Oak Ridge National Laboratory during 1961; the s highest annual shipment figure was the 222,703 curies d in 1959.

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- Private industry showed interest in taking over some of the less spectacular, but necessary, operations that will be required for the future growth and economic well-being of the private nuclear industry.
- Fundamental science made numerous gains in the fields of life science and physical research.[1]
- One private utility announced plans for building a large-scale plant (Pacific Gas and Electric Co. at Bodega Bay, Calif.) without Government financial assistance.

The atomic energy program also had its less favorable aspects during the year. Six electricity-producing reactor projects (Elk River, Piqua, Saxton, Consolidated Edison, Fermi, and Experimental Breeder Reactor No. 2) which had been scheduled to begin operating during 1961 had to be rescheduled for 1962 operation because of delays in construction and technical difficulties. Two projects (Florida West Coast, and Homogeneous Reactor Experiment) were terminated by the Commission. A proposal for a 50,000 ekw nuclear power plant (cities of Los Angeles-Pasadena project) was withdrawn because of site problems and economic considerations; another project (Southern California Edison) was stalled because of site problems; and another proposed project (Prototype Organic Cooled Power Plant) was deferred. The Commission determined that two other projects (Small Pressurized Water Reactor, and the Low Temperature Process Heat Reactor) could be deferred at this time with the least detrimental effect upon the over-all reactor program; the determination was made in connection with the President's October request to all Government agencies to postpone the initiation of deferrable projects. The first fatal reactor accident (SL–1) in the Commission's history also occurred during 1961.

In the weapons test area, the United States' voluntary suspension ended after two years and 11 months after the Soviet Union broke the moratorium with the most intensive test series in history; the Commission announced eight underground tests between September 15 and December 31.

[1] The results of Commission-sponsored fundamental research are reported in a supplemental report, "Atomic Energy Research—Life and Physical Sciences, Reactor Development, and Waste Management—1961," available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

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Award Presentation. The 1961 recipient of the Commission's prized Fermi Award was Dr. Hans A. Bethe, internationally known nuclear theoretical physicist and Professor of Physics at Cornell University. The consisted of a gold medal, a citation, and $50,000. Photo shows Dr. (center) about to receive the gold medal and check from President during a White House ceremony on December as Commission Chair- Glenn T. Seaborg looks on. In part, the citation read ". . . . in recogni- his outstanding contributions in the fields of nuclear and theoretical which helped to establish the foundations of nuclear physics and nuclear ; in the applications of atomic energy for the betterment of mankind; ons technology; and as a teacher and a leader of men." Dr. Bethe was Strasbourg, Alsace-Lorraine on July 2, 1906. During the early 1930's under Lord Rutherford at Cambridge University and Dr. Fermi in and in 1935 he came to the United States to teach at Cornell. His early nuclear physics included contributions to the theory of nuclear reac- which formed the basis for the development of atomic energy during War II. During the war, Dr. Bethe worked on the atomic weapons Los Alamos Scientific Laboratory. Since the war, he has made portant contributions in nuclear theory and participated in technical ected toward the use of nuclear energy for the production of useful The Fermi Award was established in 1956 in the name of the leader roup of scientists who successfully operated, in Chicago on December 2, world's first nuclear reactor, proving that a nuclear fission chain uld be self sustained and controlled. The recipients are named on of meritorious contributions to the development, use, or control of ergy. Previously, the Award has been made to Dr. John von Neumann, Ernest O. Lawrence, 1957; Dr. Eugene P. Wigner, 1958; and Dr. Sea- There was no award made in 1960.

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Part One

The Atomic Energy Industry and Related Activities for 1961

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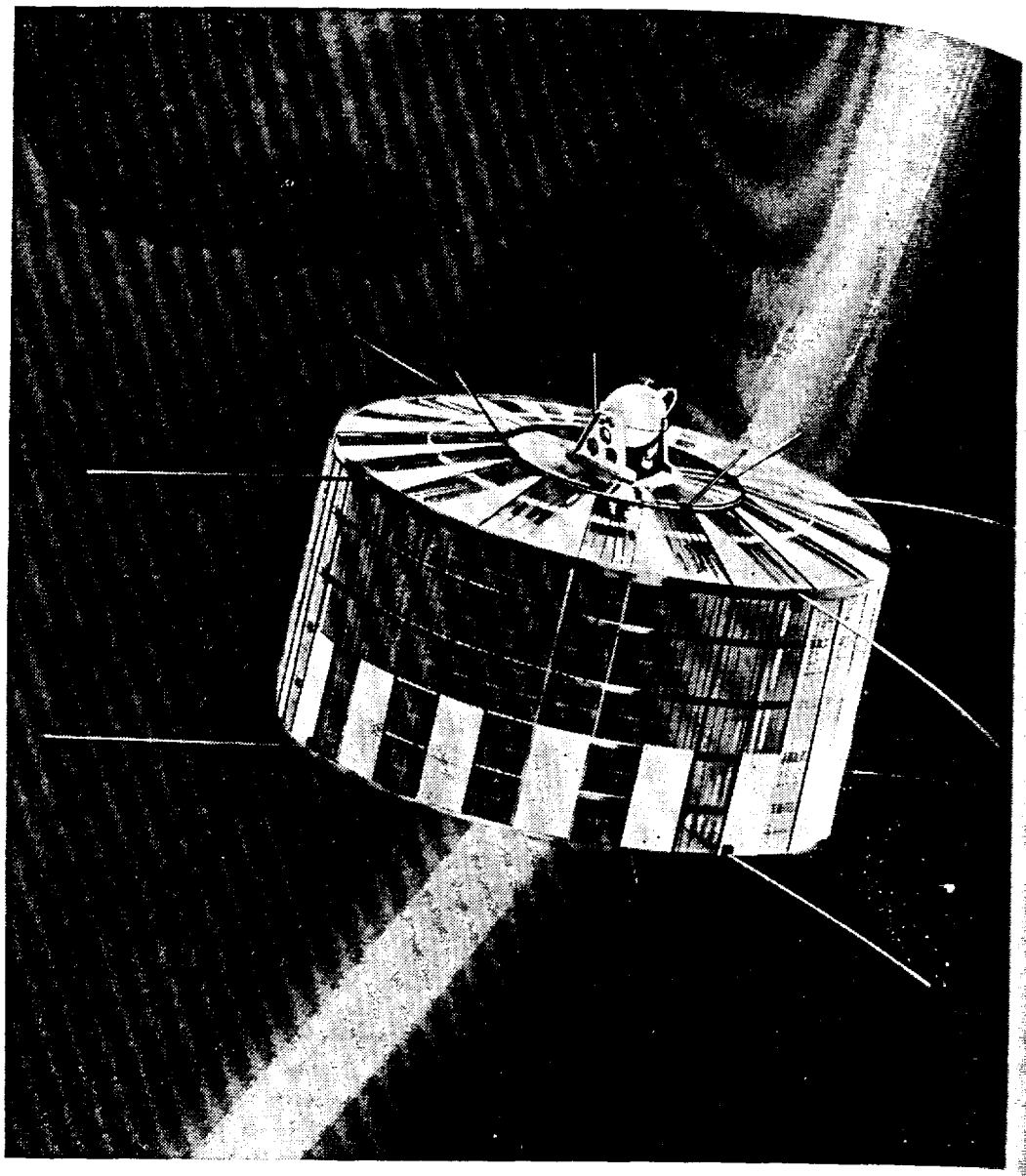

Atomic Power in Space. First of the world's satellites to use auxiliary power from nuclear energy was the TRANSIT 4A navigational aid placed in orbit from Cape Canaveral on June 29, 1961. The white sphere, atop the artist's concept of the drum-shaped satellite in orbit, is the radioisotope-fueled electricity generator which powers two of the satellite's four radio transmitters. The SNAP (Systems for Nuclear Auxiliary Power) uses thermocouples to transform heat, generated by the decaying plutonium 238 fuel, into electricity. The device was developed for the Commission by The Martin Co. and will provide power for many years. A second such unit was launched into orbit aboard the TRANSIT 4B on November 15.

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THE INDUSTRY IN GENERAL

On a dollar volume basis, the nuclear industry began the year 1961 almost three times stronger than it was in 1957, although the yearly figures for the value of shipments of atomic energy products were beginning to level off.[2] New firms, especially in the radioisotope and instrument segments of industry, continued to show a growth. A manpower survey showed that during 1961 an estimated 193,000 persons were engaged in atomic energy work, a slight rise over the 185,000 for 1960.

Although no new major nuclear power plants began producing electricity during 1961, operating experience with the Shippingport, Dresden, and Yankee stations showed that design estimates were being exceeded substantially in core-life, power output, and other factors. Seven new plants (Hallam, Consolidated Edison, Saxton, Elk River, Piqua, Fermi, and EBR–2) with a combined electrical capacity of almost 450,000 kilowatts had reached the stage in construction where, at year's end, generation of electricity could be expected by the fall of 1962. Nine other nuclear power plants, private and Commission-sponsored, are either under construction or in the final stages of planning. With a combined generating capacity of some 650,000 kilowatts, they are the Pathfinder, Carolinas Virginia, BONUS, Big Rock Point, Experimental Gas Cooled, High Temperature Gas Cooled, and LaCrosse projects which are under either full or partial Commission sponsorship, and the privately owned Humboldt Bay and Bodega Bay plants in California.

The Commission took a number of steps through the year to encourage industrial participation in the atomic energy program. For example, it withdrew from three areas of service when industry showed a capability to provide the services on an economic and competitive basis; it jointly issued with Euratom a second invitation for power reactors to be built in Europe with their designs based on types in use in the United States; and it took steps to make greater quantities of radioisotopes recovered from fission products available. Steps were taken, also, to insure that the growth of the nuclear program was carried out in a manner consistent with protecting the public health and safety.

[2] Figures for 1961 not available at time of publication of this report.

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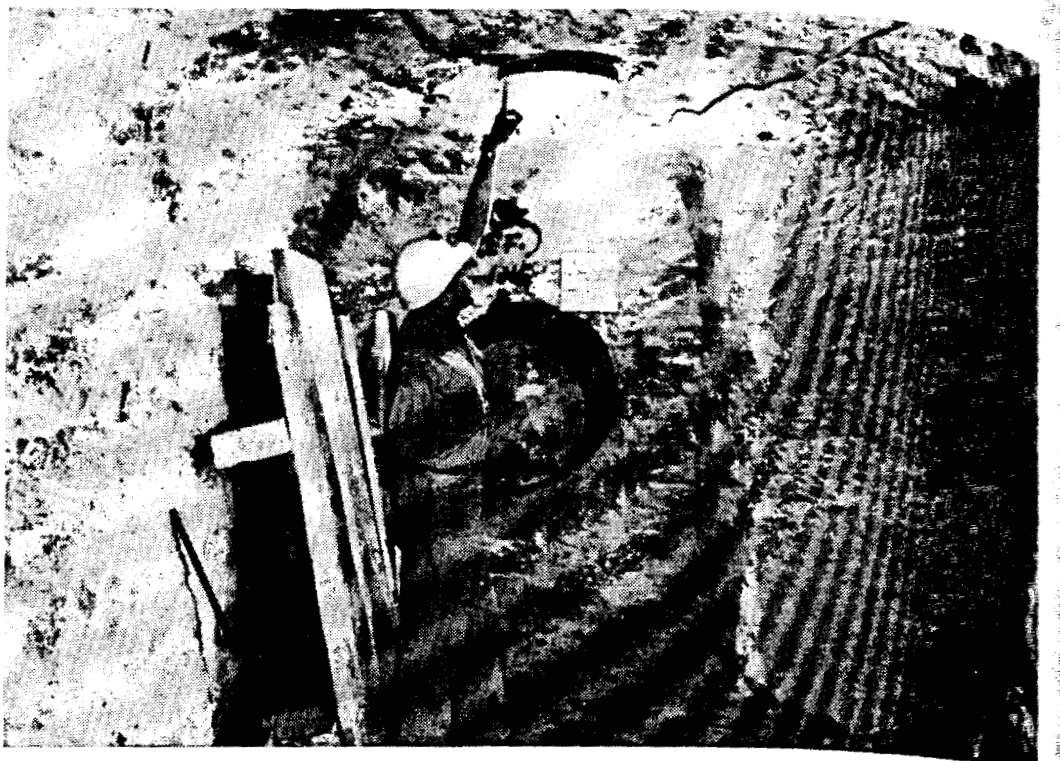
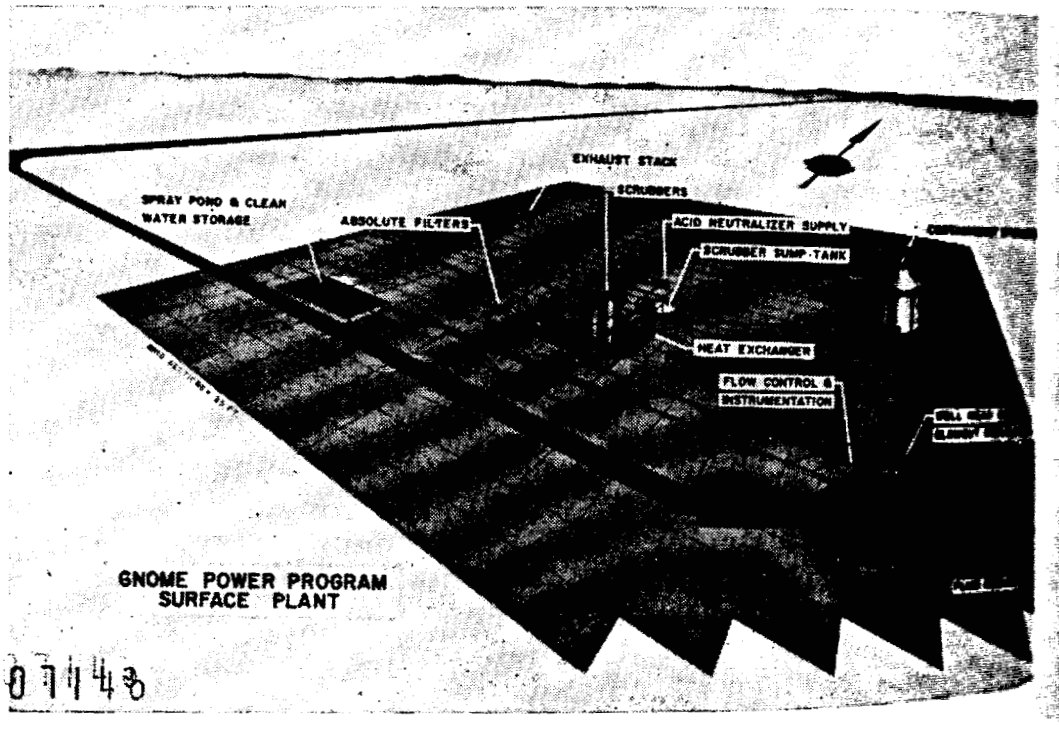


First Plowshare Experiment. The Commission's Plowshare program is devoted to the development of peaceful and beneficial uses of nuclear explosives. On December 10, the first nuclear experiment in this program, Project Gnome, was conducted in a salt formation in New Mexico. The *above* pre-experiment photo shows the "zero chamber", located 1,200 feet below the surface, where the nuclear device was detonated. The chamber was about 10 feet wide and 8 feet high. The workman is pointing to a sample hole bored into the roof of the chamber. At the center rear is a 22-inch vacuum pipe which was used in connection with basic neutron physics experiments. Drawing *below* shows the layout of equipment planned for use in evaluating the possibility that heat from such explosions could be used for the production of power. This was one of the five basic purposes for the project.



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Some of the industrial benefits that might be derived from the explosive force of the atom were under study when the first nuclear detonation of the Commission's Plowshare program was made on December 10 near Carlsbad, N. Mex. The experiment, known as Project Gnome, was carried out to obtain information related to a number of industrial and scientific applications of nuclear explosives. Further Plowshare program experiments, not yet authorized, are being planned for such peaceful industrial uses as for major excavation work and as a means of exploiting such natural resources as water, oil, and minerals.

INDUSTRY TRENDS

Dollar Volume

A mid-1961 industrial report issued jointly by the Commission and Bureau of Census showed that during 1960, total shipments—including shipments to U.S. Government agencies and exports—of selected key atomic energy products manufactured in privately owned establishments amounted to $285.6 million. This represents an increase of 15 percent above the total shown for 1959 and nearly three times the $99.6 million reported for 1957.

Table 1 shows a breakdown of the figures for the four-year period, 1957–1960.

The item which accounted for most of the increase in the value of industry's shipments between 1959 and 1960—especially in material furnished to the U.S. Government—was complete reactor fuel elements and control rods ready for installation in reactors. This was due in large part to the shipping of complete cores for naval use.

For the 1960 census, the industrial respondents were also asked to report net orders received for certain items on the survey. These net orders were defined to include:

a) the sales value of orders accepted during the reporting period for products to be delivered at some future date;
b) the sales value of orders received during the reporting period for immediate delivery; and
c) the net sales value of contract change documents which increase or decrease the sales value of the orders to which they are related when the parties concerned are in substantial agreement as to the amount involved.

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TABLE 1.—VALUE OF SHIPMENTS OF ATOMIC ENERGY PRODUCTS 1957–1960

(In thousands of dollars)

Product	1960	1959	1958	1957
TOTAL	285,647	*242,009	161,762	[illegible]
Nuclear reactors	12,389	7,497	1,156	[illegible]
Reactor components and equipment:				
Primary vessels and tanks	11,873	19,989	17,099	[illegible]
Control rod drive mechanisms and components [a]	16,227	5,404	7,481	[illegible]
Accessory instrumentation for reactor control	17,668	15,933	15,284	[illegible]
Heat exchangers and condensers [b]	19,019	27,233	13,799	[illegible]
Pressurizers, components, and auxiliary equipment [c]	2,034	3,620	1,758	[illegible]
Pumps	21,390	19,455	9,516	(d)
Valves	8,319	13,984	11,401	[illegible]
Fuel handling equipment	1,950	1,747	(d)	[illegible]
Complete reactor fuel elements and control rods shipped directly for installation or use in a reactor [e]	81,165	54,845	23,873	[illegible]
Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor [f]	14,335	11,773	5,742	[illegible]
Core structurals (barrels, cans, boxes, plates, etc., not included above)	4,034	5,255	3,908	[illegible]
Reactor moderators, coolants, and reflectors [g]	3,278	(g)	(g)	(g)
Other specialized reactor components and equipment	5,837	4,684	12,935	[illegible]
Hot laboratory equipment	4,150	*3,689	3,886	[illegible]
Shielding	5,713	*1,797	(d)	(d)
Radiation detection and monitoring devices:				
Radiation survey monitoring and control devices	30,904	*10,527	14,799	[illegible]
Radiation counting equipment		*15,486	10,387	
Radioactive isotopes shipped from plants producing isotopes	982	*459	171	[illegible]
Radiation sources and other radioactive materials produced from purchased isotopes	4,152	*3,749	3,071	[illegible]
Control and measuring devices containing radioactive isotopes	8,946	8,897	3,896	[illegible]
Commercial irradiation service	11,282	5,986	97	(NA)
Conversion of enriched uranium metal and compounds (excluding production or conversion of normal and depleted uranium)			1,503	(NA)

*Revised.
[a] Previously "Reactor control rod drive mechanisms."
[b] Previously "Heat exchangers."
[c] Previously "Pressurizers."
[d] Included with "Other specialized reactor components and equipment" in 1958 and 1957.
[e] Previously "Complete reactor fuel elements shipped directly for installation or use in a reactor."
[f] Previously "Partially fabricated fuel materials not shipped directly for use or installation in a reactor."
[g] Included in prior years as part of "Other specialized reactor components and equipment."

Source.—Current Industrial Reports, Series-M38Q(60)-1 and M38Q-09, U.S. Dept. of Commerce, Bureau of Census.

Table 2 shows the

TABLE 2.—VALUE OF N

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Reactor components and equipm	
Primary vessels and tanks	
Control rod drive mechanism	
Heat exchangers and conden	
Pressurizers, components, an	
Valves	
Fuel handling equipment	
Complete reactor fuel elemen reactor	
Partially fabricated reactor fu ly for installation or use in	
Core structurals (barrels, can	

*Included as orders were only letters of awards, or letters of int included if the parties concerned specifically authorized to be expa

Source.—Current Industrial R Commerce.

Industrial Growth

The industries resp No. 1) indicated that panies, operating 318 the nuclear energy increase of firms ent brought a response fr The largest increase tion and instrument f the business. At l existing companies, b labeled chemical comp research and developn private or Governmen specialties firm anno field, an aircraft ma facility to provide con

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Table 2 shows the results of this special part of the survey.

TABLE 2.—VALUE OF NET ORDERS * RECEIVED FOR SELECTED ATOMIC ENERGY PRODUCTS: 1960

(In thousands of dollars)

Product	Net orders received
[illegible]	93, 834
[illegible]ear reactors	7, 787
[illegible]tor components and equipment:	
Primary vessels and tanks	7, 066
Control rod drive mechanisms and components	8, 569
Heat exchangers and condensers	10, 936
Pressurizers, components, and auxiliary equipment	3, 022
Valves	9, 329
Fuel handling equipment	2, 577
Complete reactor fuel elements and control rods shipped directly for installation or use in a reactor	36, 502
Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor	6, 264
Core structurals (barrels, cans, boxes, plates, etc., not included above)	1, 782

*Included as orders were only those supported by binding legal documents, such as signed contracts, [illegible] of awards, or letters of intent. In the case of letters of intent, the full amount of sales value was [illegible] if the parties concerned were in substantial agreement on this amount; otherwise, only the funds [illegible]ically authorized to be expanded were included. Orders cancelled during the year were excluded.

[illegible].—Current Industrial Reports Series M38Q (60)-1, U.S. Department of Commerce, Bureau of [illegible].

[illegible]dustrial Growth

The industries responding to the Bureau of Census Survey (Table [illegible] 1) indicated that atomic industry during 1961 included 257 com[illegible]ies, operating 318 establishments either partially or exclusively [illegible] the nuclear energy field. This represents a small, but continuing [illegible]ease of firms entering the field since the first survey, in 1957, [illegible]ght a response from 200 companies with 223 establishments.

[illegible]he largest increase during the past year was in the area of radia[illegible] and instrument fabrication, with more than a dozen new entrants [illegible]he business. At least three new companies, or new divisions of [illegible]ing companies, began marketing radioisotopes or radioisotope-[illegible]ed chemical compounds, and three others began providing custom [illegible]rch and development services on radiation applications to meet [illegible]te or Governmental needs. Additionally, a major nonnuclear [illegible]alties firm announced its entry into the source encapsulation [illegible] an aircraft manufacturer announced the establishment of a [illegible]ity to provide commercial irradiation services, a match company

GY PRODUCTS

1958	1957
161, 762	[illegible]
1, 156	[illegible]
17, 099	[illegible]
7, 481	[illegible]
15, 284	[illegible]
13, 799	[illegible]
1, 758	(d)
9, 516	[illegible]
11, 401	[illegible]
(d)	(d)
23, 873	[illegible]
5, 742	[illegible]
3, 908	[illegible]
(e)	(e)
12, 935	[illegible]
3, 886	[illegible]
(d)	(d)
14, 799	[illegible]
10, 387	[illegible]
171	[illegible]
3, 071	[illegible]
3, 896	[illegible]
97	(NA)
1, 503	(NA)

8 and 1957.
use in a reactor.
installation in a reactor
equipment."

Dept. of Commerce, [illegible]

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entered the nuclear fuel element fabrication field, an investment firm announced it would help finance small, technically-oriented development companies in the atomic energy field, and a firm established late in 1960 began fabricating its first order for reactor control rods.

On the other hand, four major atomic firms consolidated either all or part of their operations into one new company with the aim of providing a completely integrated service in the nuclear field—research and development; ore processing; fuel, core and reactor fabrication; fuel management; cold scrap processing; and production and use of radioisotopes and other radiation energy sources. There were several firms who announced a reduction in their atomic energy activities, and at least one firm—a metalworking company—discontinued the fabrication of reactor core parts.

Instrument Industry Survey

During May, the Business and Defense Services Administration released the results of a comprehensive survey made for the Commission that showed approximately 160 concerns in the United States were engaged in the production of nuclear measuring instruments. The survey, which for the first time showed the extent of this segment of the nuclear industry, also indicated that shipments of the radiation detection or measurement devices had a value of approximately $46 million during 1959.[3]

More than 600 concerns were canvassed to reach those actually engaged in the production of nuclear measuring instruments, and the data shown in Table 3 consequently covers virtually the entire industry.

Industrial Manpower

During 1961, total employment in the atomic energy field was estimated to have been about 193,000. Included in this total figure were 138,000 persons employed by 318 industrial establishments, both privately owned and Government-owned contractor-operated, based on a survey conducted for the Commission by the U.S. Department of Labor. The U.S. Civil Service Commission's annual inventory of Federal personnel showed some 8,000 people employed in administrative and scientific duties associated with the Government's atomic energy activities.

[3] Latest obtainable figure.

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TABLE 3.—1959 SHIPM

(Quantities exp

Nuclear Monitoring Instrument
Portable Survey Meters, 50
Portable Survey Meters, 10
Fixed Monitoring Instrumen
Hand and Foot Counters [a]
Nuclear Monitoring Instruments
Air Particulate, Fixed and M
Gas and Liquid
Dosimeters and Accessories
Self-reading Dosimeters
Other Dosimeters
Dosimeter Chargers and Cha
Scalers
Decade Scalers
Binary Scalers
Amplifiers
Preamplifiers
Linear Pulse Amplifiers
Pulse Amplifiers with Discri
Pulse Amplifiers, not specifie
DC Linear Amplifiers
DC Logarithmic Amplifiers
Special Function Amplifiers f
Pulse Height Analyzers
Single Channel
Multi-channel
Nuclear Industrial Instruments
Gauging and Process Control
Radiography [b]
Count Rate Meters
Linear
Logarithmic
Differential and Ratio [a]
Miscellaneous Nuclear Instrumen
Sample Changers, Manual an
Power Supplies, Fixed Voltag
Power Supplies, Variable Volt
Detecting Heads Sold Separat
Scintillation
Proportional
Geiger
Ionization Chamber
Solid State [a]
Chemical Detection Devices a
Miscellaneous (includes items
avoid disclosure)
Radiation Sources [c]

[a] Data withheld to avoid disclosi
[b] Quantities are not additive bec
[c] Quantity figure shows number
tes in producing this number of

Source.—BD-61-100, May 25, 196

TABLE 3.—1959 SHIPMENTS OF NUCLEAR MEASURING INSTRUMENTS AND ACCESSORIES

(Quantities expressed in units; values in thousands of dollars)

	Quantity	Value
Nuclear Monitoring Instruments: Area and Personnel		
Portable Survey Meters, 50 MR/hr Maximum Range	20,607	3,941
Portable Survey Meters, 10 R/hr thru 500 R/hr Maximum Range	20,741	2,493
Fixed Monitoring Instruments	2,171	955
Hand and Foot Counters [a]	xxx	xxx
Nuclear Monitoring Instruments: Environmental		
Air Particulate, Fixed and Moving Filter	169	989
Gas and Liquid	1,719	3,533
Dosimeters and Accessories		
Self-reading Dosimeters	91,072	967
Other Dosimeters	14,549	438
Dosimeter Chargers and Charger Readers [b]	xxx	498
Scalers		
Decade Scalers	3,553	2,643
Binary Scalers	744	235
Amplifiers		
Preamplifiers	846	479
Linear Pulse Amplifiers	341	196
Pulse Amplifiers with Discriminators	625	358
Pulse Amplifiers, not specified by kind	1,340	751
DC Linear Amplifiers	959	585
DC Logarithmic Amplifiers	275	221
Special Function Amplifiers for Reactor Control	1,036	630
Pulse Height Analyzers		
Single Channel	808	839
Multi-channel	860	2,685
Nuclear Industrial Instruments		
Gauging and Process Control	1,286	6,567
Radiography [b]	xxx	257
Rate Meters		
Linear	5,261	1,385
Logarithmic	224	181
Differential and Ratio [a]	xxx	xxx
Miscellaneous Nuclear Instruments and Accessories		
Sample Changers, Manual and Automatic	1,116	914
Power Supplies, Fixed Voltage	16,071	3,533
Power Supplies, Variable Voltage	16,123	2,727
Detecting Heads Sold Separately		
Scintillation	2,126	1,087
Proportional	3,301	687
Geiger	113,073	1,610
Ionization Chamber	1,962	1,200
Solid State [a]	xxx	xxx
Chemical Detection Devices and Dosimeter Film [b]	xxx	1,955
Miscellaneous (includes items listed above for which data were withheld to avoid disclosure)	xxx	259
Radiation Sources [c]	13,869	1,638

[a] Data withheld to avoid disclosing figures for individual firms.
[b] Quantities are not additive because of dissimilarity in unit of measure.
[c] Quantity figure shows number of individual sources. There were consumed 316,248 curies of radioisotopes producing this number of sources.

Source.—BD-61-100, May 25, 1961, U.S. Department of Commerce, Washington 25, D.C.

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Also included in the total figure are an estimated 30,300 persons employed in nuclear activities by the Nation's educational institutions and the approximately 17,000 persons employed at those Commission laboratories which are contractor-operated by educational institutions rather than by industrial concerns. At year's end, the figures for educational institution employment sector were still being compiled. The educational institution survey was conducted for the Commission by the National Science Foundation in connection with its nationwide survey of scientific professional personnel at colleges and universities.

In the industrial survey, engineers, scientists, and other technical workers accounted for about 31 percent of all the employees, while skilled craftsmen accounted for another 20 percent. Of the 15 major segments of the atomic energy field, defense production facilities (uranium 235, plutonium, and weapons) employed 28.5 percent, and Commission laboratories and research facilities employed 16.5 percent of the 138,000 workers reported in the survey. Reactor design and manufacturing accounted for another 13.4 percent and the production of feed materials accounted for 8.7 percent. The remaining 32.9 percent was accounted for among the remaining 11 segments.

A more complete breakdown of the survey results is included under the Industrial Relations section in Part 3, "Major Activities," of this report.

Unique Occupations

There are at least 14 unique occupations in the atomic energy field, according to a U.S. Department of Labor study which was released during June. The study was undertaken to meet the growing need for basic information about jobs distinctive to the atomic energy industry.

The distinctive jobs were evaluated from the standpoint of job definition; education, training, and experience required; mental and physical aptitudes required; and the physical demands and working conditions placed upon an employee. The unique occupations are those of accelerator operator, chemical process operator, decontamination man, gamma facilities operator, health physicist, hot cell technician, power reactor operator, radiation monitor, radiographer, radioisotope production operator, scanner, test reactor operator, waste disposal man, and waste treatment operator.

THE RADIOISOTOPE FIELD

The Commission's radioisotope production and distribution program has had wide beneficial impact upon the Nation's well-being

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since its inception in 1946. Although use of radioisotopes accounted for only about nine percent of the total dollar volume of the atomic industry in 1960 (see Table 1), the individual effects were significant in obtaining new information through scientific research, increasing the health of the population, helping to bring to the market products of more uniform quality, and providing long-lasting sources of energy for scientific instruments in remote locations on the earth, under the sea, and in space.

Radioisotope Licenses

During the year ending November 30, 1961, the radioisotope segment of the nuclear industry continued to show a steady growth as Commission-licensed industrial users of radioisotopes increased 10.3 percent, compared with the 11 percent increase recorded in 1960 and the 16 percent rise of 1959.

Among the 1,033 new licenses issued during the year, 367 were for radioisotope utilization in the field of medicine, 338 for industrial uses, 251 for Federal and State laboratory use, and 77 for users in miscellaneous fields. As of November 30, a total of 6,512 individuals and organizations in the United States possessed byproduct material (radioisotope) licenses.

The number of new licenses issued during a year is only a partial indication of the business being done in this field. Since 1959, for example, manufacturers of gauging equipment may sell gauges under a general license, instead of under a special individual license for each user when such gauges have been manufactured pursuant to a specific license issued by the Commission.

Production and Shipments

Both production and sales of radioisotopes during 1961 showed a marked increase over the 1960 figures as a result of the resumption of operations at the Commission's Fission Product Development Laboratory (Fission Product Pilot Plant) at Oak Ridge National Laboratory. Demand for products of this laboratory reflects the first signs of success in achieving the long-range objectives of the Commission's Isotopes Development Program, among which is the development of uses for waste fission products.

As of November 30, a total of 438,205 curies had been shipped during 1961 as compared with the 191,122 curies shipped for the same period in 1960, and the 222,703 curies recorded in 1959. The gross income from radioisotope sales amounted to $2.7 million for

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the first 11 months of 1961, as compared with $1.9 million in 196 and $2.0 million in 1959.

Sales of radioisotopes from Oak Ridge National Laboratory, the Commission's primary point of shipment, now total 1,557,784 curies since the first shipment was made in August 1946. The number of individual shipments made during 1961 totaled 11,907 as compared with the 11,773 of 1960 and the 12,028 of 1959.

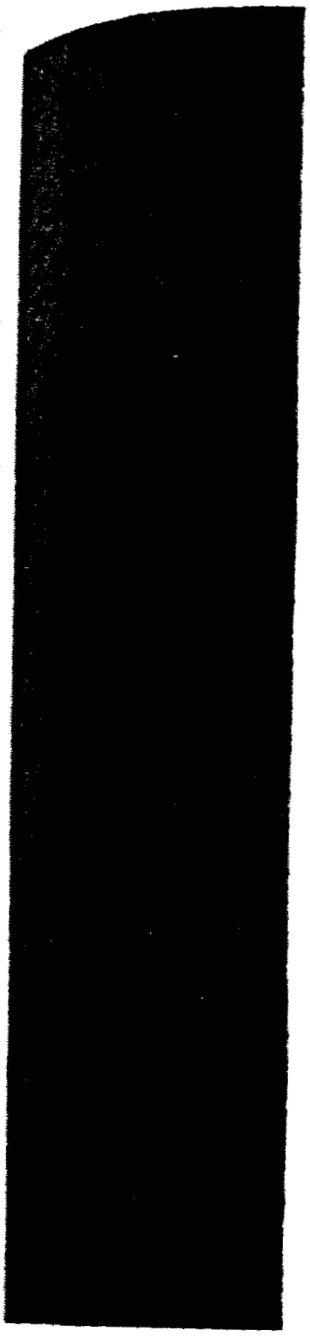
The number of shipments of radioisotopes made from Oak Ridge cannot be considered an accurate indication of the greater utilization of radioisotopes, since many of the shipments are bulk quantities furnished secondary processors. The processors break down the bulk shipments into "packaged" quantities of radioisotopes for resale.

During the year, cobalt 60 continued to be the radioisotope in greatest demand for both medical and industrial use. However, the new uses of strontium 90 and cesium 137 for heat-power sources in unmanned weather stations, navigational aids, and seismograph stations have added new major requirements for these two radioisotopes. At year's end, despite the greatly increased production of cesium 137, there was still an unfilled backlog of orders for some 330,000 curies of this radioisotope. Interestingly enough, 200,000 curies of this backlog were accounted for by two orders from secondary processors. There was also a much greater demand for carbon 14 during the past year—40 curies were shipped, as compared with the previous annual average of 7 curies.

Private Sales

During 1961, the Commission announced its withdrawal from production and distribution of cobalt 60 of the type used in radiography, teletherapy, and other common commercial applications to the extent that the isotope is available from private facilities. Both Westinghouse Electric Corp. and the General Electric Co. began using their test reactors for the commercial production of cobalt 60 in 1961. The Commission will continue to provide cobalt 60 in lots of 100,000 curies or greater to encourage research and development of applications of large radiation sources. Cobalt 60 is also being imported into the United States from foreign producers, mainly Canada.

During late 1960, Abbott Laboratories began private production and marketing of iodine 131 on a commercial basis and in early 1961 a new firm, Isoserve, Inc., began production of short-lived radioisotopes—sodium 24, potassium 42, bromine 82, copper 64—for medical, educational, and industrial customers.



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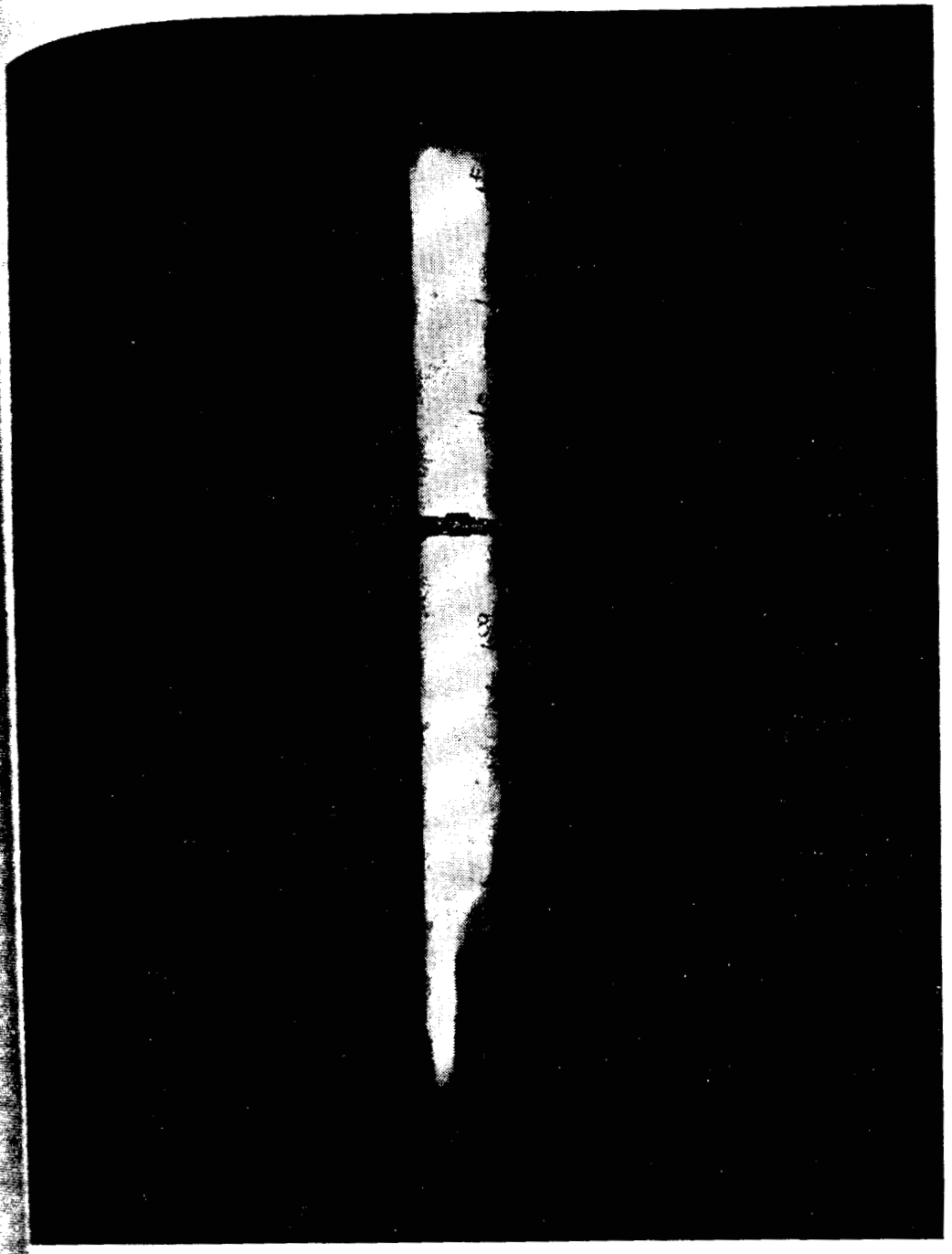

Curies of Sr-90. An ion exchange column two inches in diameter holding curies of strontium 90 furnished enough light for this picture to be taken the Commission's Hanford, Wash., plant. The photo was made through the foot-thick lead glass view window of a shielded cell in which the strontium ication process is being carried out. The crude strontium is being recovered the richly laden production streams containing plutonium, uranium, and fission products at Hanford's Purex chemical separations processing facility.

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First Shipment. The first shipment of multi-kilocurie quantities of strontium 90 and cesium 137 is shown leaving the Commission's Hanford, Wash., plant on April 8, 1961, for its transcontinental journey to Oak Ridge, Tenn. The cask containing the strontium 90 is in the large, light-colored vessel on the first car. The cesium 137 is in casks carried in the second and third cars which have been modified for this type of service. Large-scale quantities of the two radioisotopes are being recovered from the Hanford fission product waste stream and being transported to Oak Ridge National Laboratory for purification and fabrication into radioisotope-fueled power sources.

Radioisotope Recovery From Fission Products

During August, the separation and purification of fission products were resumed at the Fission Product Development Laboratory at Oak Ridge. Prior to its closure for modifications late in 1959, the facility had been called the Fission Product Pilot Plant.

The modifications increased the facility's production capacity by a factor of about 10 if its operations were to be devoted to production of a single product. The figures below illustrate the increased capability of the laboratory on the basis of multi-product, round-the-clock operation for the four principal isotopes produced for medical therapy, industrial applications, and isotopic heat and radiation sources.

Radioisotope	Old rate of production [a]	Current rate of production [b]
Cesium 137	200,000 curies per year	500,000–1,000,000 curies per year.
Strontium 90	200,000 curies per year	300,000–500,000 curies per year.
Cerium 144	2,000,000 curies per year	4,000,000.
Promethium 147	400,000 curies per year	500,000.

[a] Quantities that could be produced over one year, but all products would not be available on a simultaneous basis.

[b] Products can be made simultaneously; however, larger quantities (1,000,000 curies of cesium 137 or 500,000 curies of strontium 90) represent single product operation for the plant.

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Supply of Usefu

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Initial steps were taken during 1961 to expand as soon as possible e Commission's capacity to produce fission products for fabrication o isotopic power sources. These became necessary as successful monstrations of prototype units pointed to future needs for isotopes r in excess of the production capacity of the Fission Product Deopment Laboratory at Oak Ridge. In order to supply larger ntities of strontium 90 and cesium 137 especially, the Commission tivated two stand-by facilities to recover long-lived isotopes from te streams at its Hanford, Wash., plant. One of the facilities, "B-Canyon"—a fuel element processing plant—will provide a bility at Hanford for separation and storage of strontium and e earth concentrates during decay of objectionable short-lived opes, and permit packaging of megacurie quantities of specific fied fission products.

nford operations. Approximately 780,000 curies of strontium 90 e purified during 1961 through interim process facilities at Hanrd, and shipped to Oak Ridge for fabrication as heat sources in totype isotopic generators for the Navy, Coast Guard, and the ather Bureau. In addition, approximately 210,000 curies of parly purified cesium 137 have been recovered from the Hanford te tanks and shipped to Oak Ridge for further purification and in teletherapy and heat source applications. The shipment of e fission products in bulk form is being made in specially conrted shipping casks on railroad cars modified for the job. (See sion Product Transportation section in Part 3, "Major Activities," this report.)

n addition to meeting these immediate requirements for strontium nd cesium 137, a program is under study to provide capability at nford to produce megacurie quantities of these radioisotopes, and other selected fission products as cerium 144 and promethium 147, standard chemical form suitable for final processing and fabricainto end use devices by industry.

pic Energy Sources

e year was marked by the world's first successful use of radioe sources for energy in two orbiting satellites and at an nned weather station in the Arctic. Early in 1962, an isotopeed seismograph station will be lowered to the depths of the At, there to provide needed information about earth movements. all, the Commission's Oak Ridge National Laboratory fabricated han a dozen large-size radioisotope sources—one, a strontium 90

device, was 1,500 times larger than any such source previously made at Oak Ridge. Fission product sources totaling more than 750,000 curies of strontium 90, 330,000 curies of cesium 137, and 1,000,000 curies of cerium 144 were fabricated during 1961, or were in production at year's end, to meet the needs for radioisotope electrical power units, heat sources, and radiation sources for a variety of applications. (These sources are more fully described in the Radioisotope and Radiation Development section of Part 3, "Major Activities," of this report.)

Radiation Pasteurization of Foods

Three low-dose food research irradiators for the food pasteurization research and development program were installed during the year. Employing between 25,000 and 35,000 curies of cobalt 60 each, the units are located at the Massachusetts Institute of Technology (MIT), the University of California's Davis campus, and the University of Washington.

They can serve as on-the-spot irradiators of fish and fruit products in the program of research leading to methods of extending the refrigerated shelf-life of perishable food products by radiation pasteurization. The MIT unit was fabricated and installed by Brookhaven National Laboratory (BNL) personnel, while the two West Coast irradiators were built by Process Equipment Corp., to BNL specifications. These irradiators were designed as semi-portable units and could be moved from site to site on a trailer.

During mid-year, the Brookhaven staff completed preliminary design studies on two other types of food pasteurization units, one transportable and the other a central or in-plant unit. The unit designed to be transportable could be mounted on a railroad car or truck and moved from harvest site to harvest site. It would employ cobalt 60 sources of up to 100,000 curies of activity and could be set up in less than 48 hours by two men.

The central, or in-plant, design calls for a cobalt 60 source of approximately 300,000 curies. Such plants could be centrally located to serve the needs of a large, diversified fish processing area in much the same manner as do today's central ice or freezing plants, or they could be "tailored" for pasteurization of specific types of foods being processed by a specific firm.

THE INTERNATIONAL MARKET

United States industry continued its active participation, either directly or through foreign subsidiaries, in nuclear activities abroad

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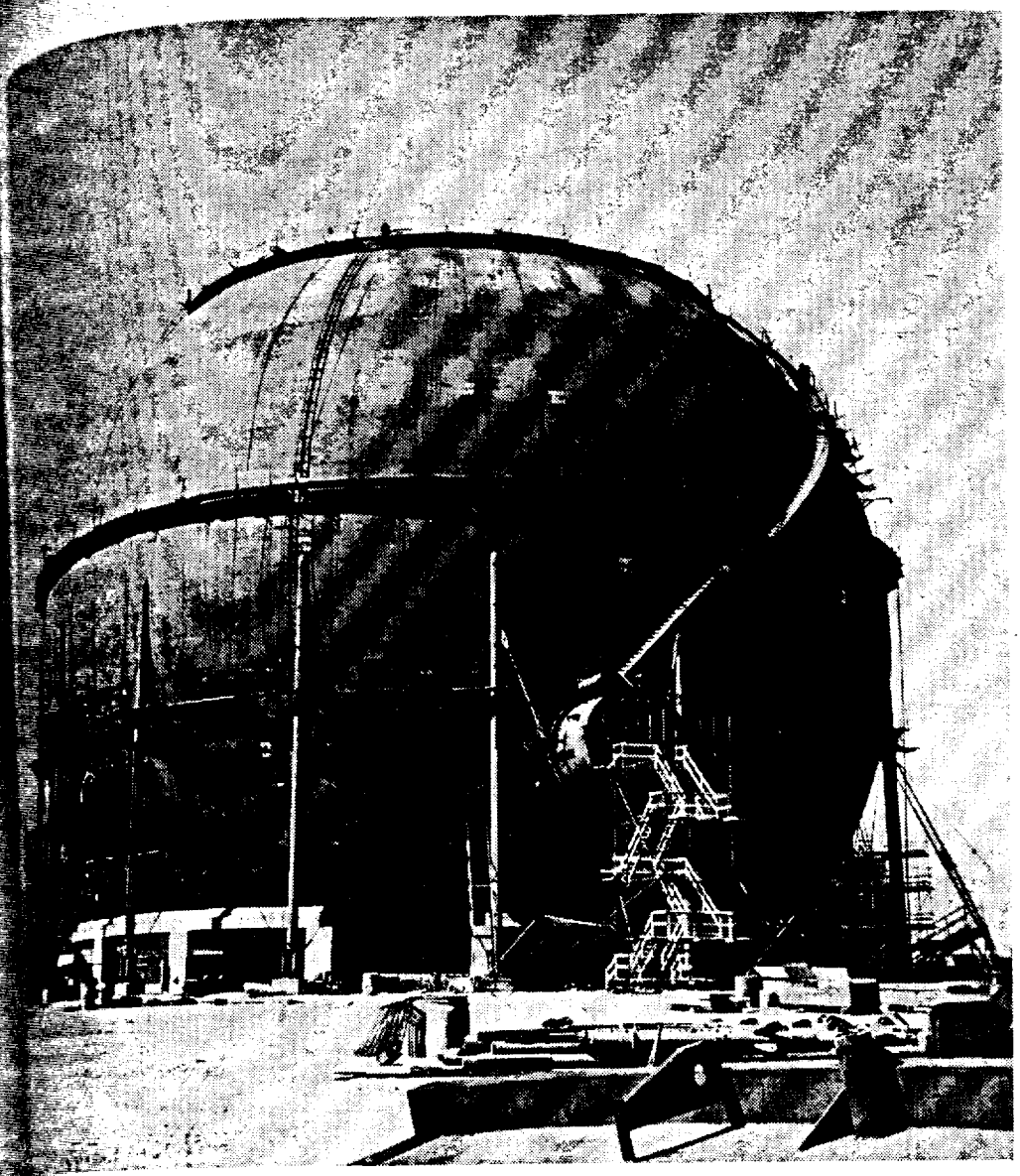

atom Project. Photo shows the nearly complete containment sphere of the 0 electrical kilowatt reactor plant being constructed in Italy by the ta Elletronucleare Nazionale (SENN) under the first joint Commission- atom reactor project invitation issued in 1959. The plant, similar to the en Nuclear Power Station in Illinois, is scheduled to start operation in It will utilize a dual-cycle boiling water reactor being built by the Inter- al General Electric Co.

g 1961. Highlights of these and related Commission activities escribed below. More complete details are included under the ational Activities section in Part 3, "Major Activities," of this t.

dom Cooperation

September 2, the Commission and Euratom issued the second tion for proposals from private or governmental organizations

within the European Atomic Energy Community—Belgium, France, The Federal Republic of Germany, Italy, Luxembourg, and The Netherlands—for the construction of large-scale, U.S. design nuclear power plants to begin operating not later than December 31, 1963. The invitation gives preference to proposals for reactors having a nuclear capacity of at least 150,000 electrical kilowatts net, although smaller plants will be considered if they present some special interest for the over-all reactor program. June 1, 1962, is the cut-off date for submission of proposals.

Under the first (1959) U.S.-Euratom invitation, the International General Electric Co. is constructing a dual-cycle, 150,000 electrical kilowatt (ekw) boiling water reactor plant for the *Societa Elettronucleare Nazionale* (*SENN*) near Punta Fiume, Italy.

The U.S.-Euratom Joint Reactor Board announced on October 31, 1961, that *the Franco-Belgian Society for Nuclear Energy of Ardennes* (*SENA*) had submitted the first proposal under the second invitation with plans for a 242,000 electrical kilowatt pressurized water reactor to be built near Givet, France. A group of seven French companies (FRAMATOME), three Belgian firms, and Westinghouse Electric International Co. will supply the plant equipment.

Possible proposals. Atomics International has undertaken for the German firm, *Baden Wurttemberg Nuclear Power Plant Planning Association* (*KBWP*), a feasibility study for a 150,000 electrical kilowatt organic cooled and moderated power reactor. The results of this study, which is expected to be completed by mid-1962, will determine whether KBWP will submit a reactor proposal under the U.S.-Euratom second-round invitation.

SELNI request. The *SELNI* Nuclear Co., for which Westinghouse is building a 165,000 electrical kilowatt pressurized water reactor, has applied for entry under the second phase of the joint program for its fuel arrangements. This reactor-plant is already under construction near Milan, Italy, and if not admitted into the joint program will be fueled under the U.S.-Italian bilateral agreement for cooperation.

Joint Research and Development Projects. The total number of U.S.-Euratom Joint Research and Development Program research contracts for work carried out in the United States increased from two in 1959 to a total of ten in 1960 and to a total of 20 as of September 30, 1961. The Joint Research and Development Board has authorized expenditure of $4,241,214 for this work in the United States. In addition, the Board has authorized two U.S. participants to assist in projects at Fiat, Italy, and Mol, Belgium, at an authorized cost of $77,770 for both. All research carried out under the joint

program is directe
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U.S. Reactor Proje

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Long-term Fuel Gua

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program is directed toward those types of power reactors to be built under the U.S.-Euratom cooperative program.

U.S. Reactor Projects Abroad

As of December 30, 1961, there were 17 research and power reactors being built in the United States for delivery abroad. This number includes power reactors in Belgium, Japan and Italy (2); and 13 testing, research, and teaching reactors in The Netherlands, Iran, Italy, Korea, Philippines, Thailand, Turkey, Viet Nam, Austria, Pakistan, Indonesia, Finland, and Japan. In all, 33 U.S.-built testing, research, and teaching reactors are now operable in 18 countries and West Berlin. The first U.S.-built power reactor abroad, the 15,000 electrical kilowatt boiling water reactor constructed by General Electric at Kahl-am-Main, Germany, produced its first electric power in June 1961, and achieved full power operation in October. This reactor is also noteworthy in that it is the first privately financed power reactor in Europe. (See also table on Reactors Built, Building, or Planned, Appendix 10.)

Long-term Fuel Guarantees

In an address before the U.S.-Japanese Atomic Industrial Forum meeting in Tokyo on December 5, 1961, Commissioner Robert E. Wilson announced the following Commission determinations regarding the sale of enriched uranium fuel to other countries on a long term basis:

- The Commission is prepared to sell to other nations, under agreements for cooperation, the material to meet their requirements for enriched reactor fuel.
- Requirements contracts will be negotiated covering up to a 25-year supply of fuel for a specified reactor, or group of reactors, with a right of cancellation on the part of the purchaser on five years' notice.
- Special nuclear materials will be sold to bilateral partners at prices identical with those charged U.S. industry.
- Reprocessing charges will be the same for foreign as for domestic operators.

Revised Charges for Enriched and Depleted Uranium

On July 1, 1961, the Commission reduced its base charges for enriched and depleted uranium and increased its use-charge rate from

4 to 4¾ percent. These changes apply to both domestic and foreign users, and the net result is expected to be to encourage construction of enriched uranium reactors abroad.

Fuel Fabrication

Fabrication of reactor fuel for reactors abroad continues to be carried out by a number of U.S. firms. Among those companies supplying enriched fuel elements for foreign reactors are: United Nuclear Corp., Sylcor, Davison Chemical Co., Aerojet General, Atomics International, General Electric, AMF Atomics, and Babcock and Wilcox.

During 1961, the Commission decided to consider requests from countries having bilateral agreements with the U.S., for an amendment to their agreements to enable these countries to fabricate special nuclear material supplied by the United States for use in another country. This change is in line with the Commission's desire to encourage the use of enriched uranium.

International Conferences and Exhibits

The Commission's international conference and exhibit programs support the growth of peaceful nuclear energy utilization throughout the world. The United States nuclear industry, in turn, provides strong support for these two programs. More complete details on the subjects mentioned below will be found in the International Activities section of Part 3, "Major Activities," of this report.

Scientific Conferences

A total of 25 international scientific meetings sponsored by both American scientific or educational institutions and international scientific or governmental organizations received assistance from the Commission during 1961. The Commission makes administrative arrangements and in some instances provides travel funds for U.S. delegates to meetings. The International Atomic Energy Agency (IAEA) Conference on Plasma Physics and Controlled Fusion Research, held in Salzburg, Austria, is the largest conference that the IAEA has sponsored. The Commission financed the travel for 36 of the [illegible] delegates to this conference. Expenses of the other delegates were funded, for the most part, by private industry or educational groups. Six of the American delegates to the IAEA Conference on Nuclear Electronics, Belgrade, Yugoslavia, were sent at industry expense.

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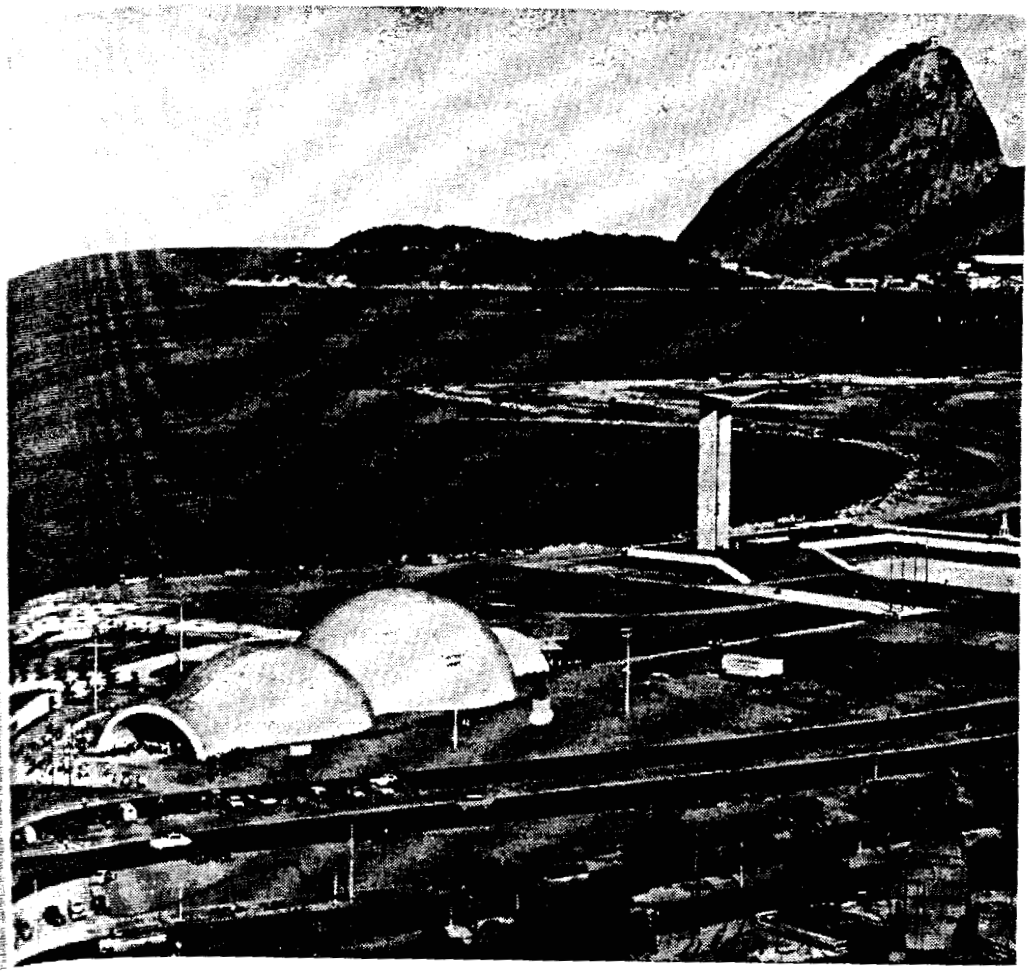

de Janeiro Exhibit. Some 200,000 Brazilians visited the Commission's ...ons at Work" exhibit when it was shown in Rio de Janeiro during May and ...e 1961. The exhibit was located on the edge of Guanabara Bay overlooked ...amed Sugarloaf Mountain. The unique display building consists of two skins ...ryl-coated nylon fabric separated by four feet of air space and is com-...ely supported by air blown into the building continuously. The structure is ...erecting in less than 30 minutes after the inflation blowers are started, and ...-foot inside length offers 22,000 square feet of uninterrupted exhibit ...e.

...ough the Commission coordinated participation for the 23-man ...ed States group.

...erial Participation in Exhibits

...er 200 American industrial concerns have displayed their prod-...broad in connection with the Commission's international nuclear ...y exhibit. While the industrial equipment displayed at exhibits ...conventional manufacturers' plates, there is no sales activity at ...es; the exhibits are scientific and educational in nature, rather ...commercial. As a direct result of this industrial participation,

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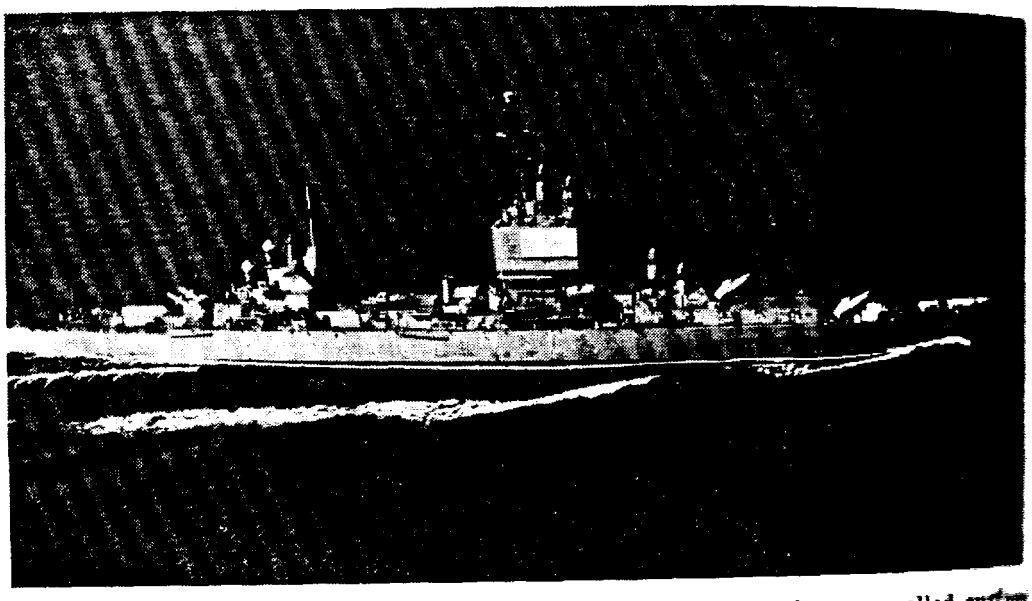
however, two sales consummated during 1961 were reported to the Commission. Kinki University at Osaka, Japan, purchased American Standard's University Training Reactor (UTR-O) leased by the Commission for inclusion in the Tokyo exhibit (May 5–22, 1959). Alderson Research Laboratories, Inc., sold a radiation equivalent manikin in Brazil after a similar piece of equipment had been displayed in the Rio de Janeiro exhibit (May 3–June 4, 1961).

The Commission leases operating research and training reactors under contract and provides funds to Brookhaven National Laboratory for design and fabrication of gamma facilities. All of the remaining operating equipment is lent by firms which make available the latest transistorized nuclear instrumentation for inclusion at particular exhibits. During 1961, for example, approximately 40 industrial organizations contributed products or services to the Latin American exhibits shown at Rio de Janeiro, Brazil, and Lima, Peru (October 7–November 7); approximately 30 participated in the exhibit at Beirut (October 8–November 8). In addition to the major pieces of nuclear equipment previously mentioned, the Commission procures from industry numerous small exhibit components and parts and such services as building design and fabrication, and expert packing. (Additional details on these exhibits will be found under "International Nuclear Energy Exhibits" in Part 3 of this report.)



Nuclear-propelled Cruiser. First of the U.S. Navy's nuclear-propelled surface ships to join the fleet was the guided missile cruiser *Long Beach* which was commissioned on September 9, 1961. During November, the nuclear-powered aircraft carrier *Enterprise* also was commissioned. The *Long Beach* uses two pressurized water reactors for propulsion power while the *Enterprise* has eight. Both ships have been termed "very fast and maneuverable." In addition, the Navy had 24 nuclear-propelled submarines in operation by the end of 1961.

SPACE

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SPACE AND MILITARY REACTOR ACTIVITY

The year 1961 was one in which atomic energy was extended to new frontiers, not only to distant places on this planet such as the South Polar areas, but also into space. Additionally, the U.S. Navy commissioned its first two nuclear-propelled surface ships.

A major milestone was reached in the United States space program on June 29 with the orbiting of a U.S. Navy TRANSIT–4A navigational satellite using a plutonium 238-fueled thermoelectric generator as a power source. The presence of the "atomic battery" in the satellite marked the first time that nuclear energy has been used in space and was a major advancement in the Commission's program to develop compact nuclear power sources. A second navigational satellite, TRANSIT–4B, was launched on November 15 and is also transmitting signals successfully using a similar nuclear power source.

The five pound, 2.7 watt generators are powering two of the four navigational transmitters in each of the satellites which are sending data back to earth. They are designed to perform for five years. These small generators are the first step in the program now underway to develop a radioisotope thermoelectric generator for the operational TRANSIT navigational system. The two satellites are prototypes of a series which will provide accurate sightings for ships and planes under all weather conditions. Other work is going forward on Systems for Nuclear Auxiliary Power (SNAP) using both radioisotope units and small reactor units in space vehicles.

Significant progress is being made on another important use of power generation in space exploration, the use of nuclear energy as propulsion—getting vehicles into space and equipping them with power for travel over great distances. Work is moving forward on the Joint Commission–National Aeronautics and Space Administration Project ROVER nuclear rocket program to develop propulsion systems for manned or unmanned space exploration. Such nuclear systems should have significant advantages over chemical rockets because of their greater thrust per pound of propellant flow. The ROVER reactors are designed to heat hydrogen, the most efficient propellant, at high temperatures, and then to expel it through a jet nozzle. Several non-flyable experimental reactor tests have been conducted—the latest being in December—using gaseous hydrogen as a propellant. This series will be continued in 1962 using liquid hydrogen. The success of the tests thus far permits reasonable expectation of rapid technical progress toward flight performance reactors.

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Reactor tests also were conducted during 1961 on Project PLUTO, which is designed to demonstrate the feasibility of a nuclear ramjet engine for use in strategic missiles under a Joint Commission-Air Force program. During these reactor power runs, temperatures in excess of 2,000° F. were attained in the reactor core. The next step in the program is testing of a flight-type reactor which could provide a propulsion system for low-altitude supersonic flights.

While the nuclear space effort continued at an accelerated pace during the year, the Commission-Air Force program for nuclear propelled aircraft was terminated in March by Presidential decision. All work was cancelled on the direct and indirect cycle reactors oriented toward an actual manned aircraft application. The 10 thermal megawatt, lithium cooled reactor experiment planned for the indirect cycle approach was redesigned and reoriented to an advanced high temperature reactor experiment to further lithium cooled reactor technology. A high temperature materials program was initiated at the former aircraft contractors' sites to advance materials technology and to utilize the capabilities and experience of the personnel at these sites.

The land frontiers of nuclear power were extended in 1961 to the South Polar continent of Antarctica. In October, a SNAP radioisotope device was delivered to the Navy for shipment to the Antarctic to power an automatic weather station. The station will be similar to the unmanned weather station put into operation in the Arctic earlier in the year by the U.S. Weather Bureau. Early in November, reactor components of the Portable Medium Power Plant No. 3A (PM–3A), developed under the Commission's Army Reactors program, were shipped to the Antarctic for installation at McMurdo Sound. This plant is to provide electricity and heat for melting snow at the Naval Air Facility there. Another Army Reactor, the Portable Low Power Plant No. 3, is planned for installation in an ice tunnel at Byrd Station in the interior of Antarctica.

The operation of the PM–3A at McMurdo Sound will mark the first use of a land-based power reactor not only in the Antarctic but anywhere south of the equator. This, of course, excludes the use of nuclear-powered submarines which have previously operated in Southern Hemispheric waters.

The nuclear-powered fleet continues to grow, increasing from 14 operating submarines at the end of 1960 to 24 operating submarines, one guided missile cruiser, and one aircraft carrier by the end of 1961. The cruiser *Long Beach*, commissioned on September 9, became this nation's first operating nuclear-powered surface vessel. The large aircraft carrier *Enterprise*, powered by eight reactors, was commissioned on November 25. The total number of nuclear-powered Navy

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sels authorized, including those operating, is 61 submarines and surface vessels.

A detailed account of Commission projects in the space and military lds is carried in Part 2, the Nuclear Power Program, of this report.

THE CIVILIAN NUCLEAR POWER PROGRAM

In summarizing reactor construction and operating activities ring 1961, it can be stated in general terms that operating activities ere encouraging while construction activities were discouraging. s a result of the successful operation of three large-scale power ctors, plus the support of three experimental plants, some elec- city was produced by nuclear energy nearly every day of the year. n the other hand, several other reactors which were expected to be erating in 1961 did not achieve criticality because of delays in con- ction or technical difficulties.

OPERATIONAL EXPERIENCE

Encouraging operating history during the year was provided by the ppingport Atomic Power Station, the Dresden Nuclear Power tion, and the Yankee Nuclear Power Station. Together, these ctor plants generated almost two billion kilowatt hours of elec- ity during the year, four times as much as was generated in any ious year. In 1961, several hundred thousand families were ished atomic electric power for cooking, lighting, heating, cooling, other services in various parts of the country.

he nuclear success story of 1961 was provided by the Yankee Re- at Rowe, Mass. The plant was built and put into operation at al cost to Yankee of $43.7 million as against the original estimates million. Company officials are predicting 11–13 mills per kilo- hour (m/kwh) power on the first core as compared with previous ates of 12–14 m/kwh only after the third or fourth core had been ed.

the beginning of the year, the reactor attained for the first time ll design power of 110,000 electrical kilowatts (ekw). In light reactor's operating experience at this power level, the company sed and the Commission approved an amendment of its license to permit operation at 485 megawatts thermal (Mwt), which sidered to be the equivalent of about 136,000 ekw. Subsequent tion at this thermal capacity provided an even higher electric

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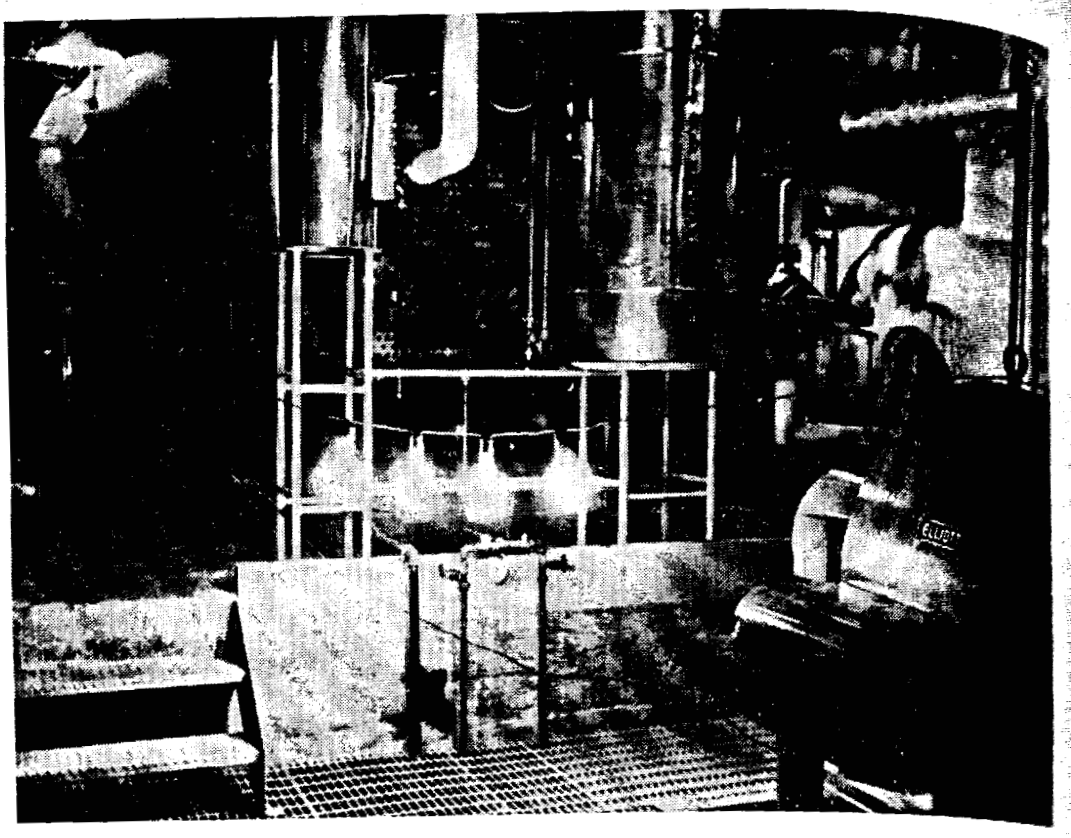
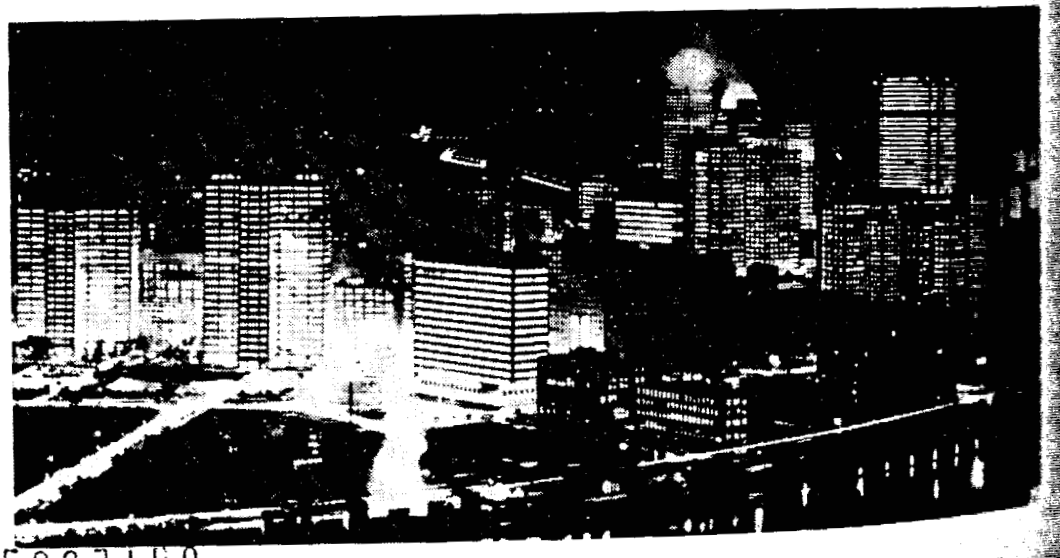


Nuclear Electricity. The glowing electric lights in the *photo above* are the first known use of electric power produced through atomic energy. The photo was taken on December 20, 1951, at the Commission's National Reactor Testing Station in Idaho when the Experimental Breeder Reactor No. 1 (EBR-1) was put into operation. Built by Argonne National Laboratory, the EBR-1 (not shown in photo) had a core the size of a football and gave off enough heat for the generator (shown at right) to produce 150 kilowatts of electricity. Photo *below* shows the lights of downtown Pittsburgh, Pa., which receives a part of its electricity from the Commission's Shippingport Atomic Power Station through the distribution network of the Duquesne Light Co. (photo courtesy of Westinghouse Electric Corp.).



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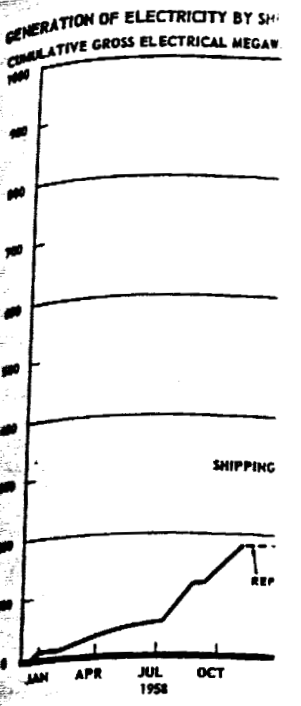

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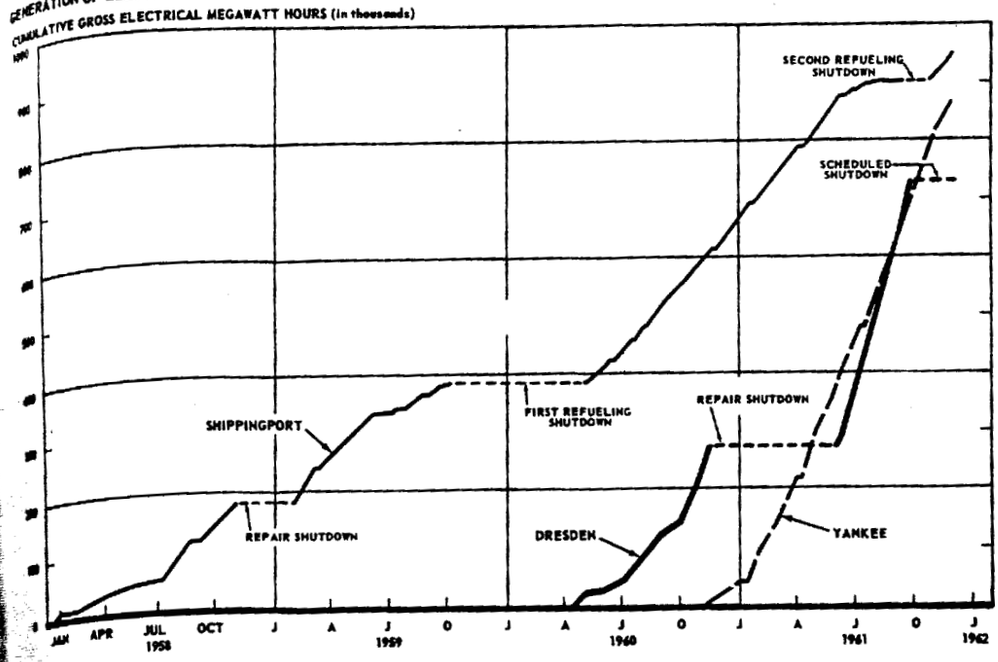
GENERATION OF ELECTRICITY BY SHIPPINGPORT, DRESDEN, AND YANKEE PLANTS



generating capability—141,000 ekw. Reactor operation was unusually smooth, with the plant experiencing very little downtime. This was a very heartening situation for a new plant just going on the line.

Encouraging results also were obtained from the Shippingport plant, which completed its fourth year of operation in December. The reactor was shut down in August for its second refueling of seed elements, a task which took only 44 working days—as compared with the working days required for the first refueling. The blanket elements are still in the core and have far surpassed their design lifetime of 8,000 equivalent full power hours. Inspection of these elements during the second refueling indicated that they probably could be operated successfully through a fourth seed lifetime. Because of the extended lifetime of the first core blanket, the second core, which will increase the power capability from 68,000 to 150,000 gross electrical kilowatts, will probably not be loaded until 1963.

Although the 180,000 ekw Dresden plant—still the largest operating reactor in the country—continued to be shut down[4] during the first part of 1961 because of component problems, operation was very satisfactory when resumed at the beginning of June. The power level was maintained at full, or nearly full, design power for most of the remainder of the year and operation was relatively trouble-free.

[4] The reactor was shut down on November 15, 1960, because of control rod difficulties. When it was found that a control rod drive tube had severed and a second drive tube showed evidence of cracking, it was decided to remove the entire core and examine all drive tubes.

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The mechanical trouble which the Dresden reactor experienced early in the year—that of cracking of 17–4 PH stainless steel control rod drive components—led to reexamination of components in other reactors under construction. This was because the type of stainless steel which developed cracks in the Dresden plant also was employed in most of the other water reactors being built.

STATUS OF PROJECTS

Several plants did not meet their 1961 criticality schedules because of developmental problems such as fuel fabrication difficulties, pressure vessel cladding cracks, procurement delays, or labor union strikes.

The only new reactor that achieved criticality in 1961 was the small experimental scale Los Alamos Molten Plutonium Reactor Experiment (LAMPRE). The delayed projects now scheduled for initial operation in 1962 are the Elk River Reactor, Consolidated Edison Thorium Reactor, Saxton Nuclear Experimental Reactor, Boiling Water Experiment No. 5 (BORAX–5), the Heavy Water Components Test Reactor, the Piqua Nuclear Power Facility, the Experimental Breeder Reactor No. 2, and the Enrico Fermi Atomic Power Plant.

Litigation regarding the Commission's issuance of a construction permit for the Fermi project was resolved by the United States Supreme Court in favor of the Government. More construction time was needed, however, to replace graphite shielding which deteriorated under test and to take care of other developmental matters. It was necessary, therefore, to extend the completion date to the summer of 1962.

The Elk River (Minn.) reactor has experienced an extended delay mainly because of problems with the reactor vessel. Corrective steps are being taken and further tests are underway, but the public hearing necessary prior to issuance of the operating authorization will not be held until all questions on the reactor vessel have been satisfactorily resolved.

While some projects experienced delays during construction, others experienced lengthy delays before construction started. Construction of the High Temperature Gas Cooled Reactor proposed by the Philadelphia Electric Co. was scheduled to start at Peach Bottom, Pa., in April 1961, but will probably not get underway until the spring of 1962 because additional technological data were needed before a construction permit could be issued by the Commission. These data were supplied and a public hearing on the issuance of a construction permit was held during December 1961. The matter was pending with the Hearing Examiner at the year's end.

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TABLE 4.—CIVIL

Private Industry
Vallecitos Boiling Water
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Humboldt Bay Reactor
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Ultra High Temperature
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TABLE 4.—CIVILIAN POWER REACTOR PROJECTS BY TYPE OF ARRANGEMENT AND STATUS

	Status	Power (ekw)
Private Industry		
Vallecitos Boiling Water Reactor	Operable	5,000
Dresden Nuclear Power Station	Operable	180,000
Saxton Nuclear Experimental Reactor	Construction	3,250
Consolidated Edison Thorium Reactor	Construction	[a] 255,000
Humboldt Bay Reactor	Construction	48,500
Vallecitos Experimental Superheat Reactor	Construction	0
Bodega Bay Reactor	Design	313,000
Government		
Experimental Breeder Reactor No. 1	Operable	150
Experimental Boiling Water Reactor	Operable	4,500
Organic Moderated Reactor Experiment	Operable	0
Plutonium Recycle Test Reactor	Operable	0
Los Alamos Molten Plutonium Reactor Experiment	Operable	0
Boiling Reactor Experiment No. 5	Construction	2,650
Heavy Water Components Test Reactor	Construction	0
Experimental Breeder Reactor No. 2	Construction	16,500
Experimental Organic Cooled Reactor	Construction	0
Molton Salt Reactor Experiment	Design	0
Ultra High Temperature Reactor Experiment	Design	0
Experimental Beryllium Oxide Reactor	Design	0
Government—With Utility Participation		
Shippingport Atomic Power Station	Operable	60,000
Sodium Reactor Experiment	Operable	6,000
Experimental Gas Cooled Reactor	Construction	23,200
Cooperative Power Demonstration Projects [b]		
Second Round Type Arrangement		
Hallam Nuclear Power Facility [c]	Construction	75,000
Elk River Reactor	Construction	[a] 22,000
Piqua Nuclear Power Facility	Construction	11,400
Boiling Nuclear Superheat Reactor	Construction	16,300
La Crosse Boiling Water Reactor	Design	50,000
Third Round Type Arrangement		
Yankee Atomic Power Station [c]	Operable	141,000
Enrico Fermi Atomic Power Plant [c]	Construction	60,000
Pathfinder Atomic Power Plant	Construction	62,000
Carolinas-Virginia Tube Reactor	Construction	[a] 17,000
Big Rock Point Plant	Construction	47,800
High Temperature Gas Cooled Reactor	Design	40,000

[a] Includes some oil-fired superheat.
[b] See "Progress in Power Reactor Technology" in Part 2 of this report for description of types of arrangements.
[c] Proposal submitted in response to first round invitation.

Consideration of the proposed cooperative project with the cities of Los Angeles and Pasadena regarding a 50,000 ekw boiling water reactor was halted in February when the two cities withdrew their proposal because of site problems and economic considerations. Later in the year this reactor project was reactivated as the LaCrosse Boiling Water Reactor project as a result of an unsolicited proposal from the Dairyland Power Cooperative, LaCrosse, Wis.

In November the Commission reached the decision not to go forward on the Small Pressurized Water Reactor and the Low Temperature Process Heat Reactor projects. The Commission determined that the two projects could be deferred with the least detrimental effect on its over-all reactor program. The action was taken in conjunction with the President's request in October to all Federal agencies to postpone the initiation of deferrable projects. It is expected that selected research and development applicable to these two reactor types will be continued.

Since the Commission was unable, in 1960, to obtain any proposals of a third-round type (Commission pays for certain research and development) for a prototype organic-cooled power reactor, an invitation was extended during 1961 for proposals on a second-round basis (under which the Commission owns the reactor). Only one proposal was received in response to this invitation and it was not satisfactory. In light of the President's request to postpone the initiation of deferrable projects, the Commission has decided to defer construction of this project.

Because of technical and economic uncertainties, the 50,000 ekw gas-cooled, heavy-water reactor planned for construction in Western Florida was terminated in May. The Commission, after evaluating the project, decided to terminate rather than to continue the research and development program for another two years as was proposed by the East Central and Florida West Coast Nuclear Groups. Participation of the companies in the Commission's program has not been lost, however, for the East Central Group has agreed to conduct an evaluation of various heavy water reactor systems from a utility point of view using data from the Commission program.

Also, because of various technical and economic reasons, work on the aqueous homogeneous reactor concept was phased out at the end of fiscal year 1961. This included shutting down and placing in storage the Homogeneous Reactor Experiment No. 2 at Oak Ridge, Tenn. Much of the previous effort on fluid fuel systems at Oak Ridge is now being concentrated on the Molten Salt reactor system. Facility modification began in May for construction of a reactor experiment of that type.

Negotiation on the Southern California Edison Co. and the Westinghouse Electric Corp. proposal regarding a 355,000 ekw pressurized water reactor scheduled to be built on the Southern California coast was at a standstill pending resolution of site problems. A long-term lease is being sought by the utility firm for a site on the Marine Corps reservation at Camp Pendleton, Calif.

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on the construction schedule, the Pacific Gas and Electric Co. announced, in June, plans to build a 313,000 ekw boiling water reactor at Bodega Bay, about 50 miles north of San Francisco. Construction of this privately owned plant is expected to get underway in the latter half of 1962. Both the Bodega Bay Reactor and the proposed Southern California Edison Reactor are tentatively scheduled for completion in 1965, and the Humboldt Bay plant in 1962. The two large-scale plants are expected to be competitive with fossil fueled plants in those areas over their lifetimes. The operation of these plants on this basis would be considered an important step towards the Commission's general goal of economic nuclear power.

In spite of the delay of numerous projects during 1961, the Commission has not altered its basic objectives for the Civilian Nuclear Power Program. The Commission's short-range objective is to make it possible by 1968 for utility owners in high energy cost areas to elect, on the basis of economic considerations, to build large nuclear plants rather than conventional plants.

A longer-range objective is to achieve such technological advances as to enable ever-increasing numbers of U.S. utility owners in the 1970's to make such choices in widening ranges of locations using various reactor types and sizes.

The reactor types which are expected to attain the short-range goal of economic nuclear power in high fuel cost areas by 1968 are the pressurized and boiling water concepts. Other concepts such as the organic, sodium, or gas cooled reactors may show a greater capability to achieve the long-range objective of economic nuclear power in ever widening areas of the United States by the 1970's.

Therefore, to achieve both the short- and long-range objectives, the Commission is carrying out a broadly based reactor development program embodying several different concepts. The section on Progress in Power Reactor Technology, in Part 2 of this report, includes a status report of the projects in each concept now being developed.

Development Work in Industrial Laboratories

Reactor development work conducted for the Commission by private industrial organizations, largely in their own facilities, rose above $100 million annually for the first time in the fiscal year ended June 30, 1961. The increase of $18.6 million, or 20 percent, over the comparable amount for the fiscal year ended June 30, 1960, also reflected a more than proportional share the increase in the total amount spent by the Commission on such work. Amounts spent with other types of organizations increased only 17 percent. The distribution of

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these funds in the past four fiscal years is shown in Table 5. The percentage of total Commission reactor development funds spent directly for work in private industrial organizations has risen each year, from 17 percent in the 1958 fiscal year to 27 percent in the 1961 fiscal year.

TABLE 5.—DISTRIBUTION OF AEC REACTOR RESEARCH AND DEVELOPMENT EXPENDITURES

Type of organization	Fiscal year (millions of dollars)			
	1958	1959	1960	1961
Industrial	49.1	75.9	94.1	[illegible]
AEC laboratories	237.3	246.0	260.9	[illegible]
Universities	.8	1.3	1.5	[illegible]
Other non-profit	1.8	1.3	2.6	[illegible]
Other Government	1.2	1.7	2.6	[illegible]
Total *	290.2	326.2	361.7	[illegible]

* These totals do not include depreciation on Commission-owned facilities or special nuclear materials consumed. Such costs are included in costs reported for reactor development work in the Annual Financial Report, Appendix 16.

The Reactor Industry

At mid-1961, 65 reactors of all types were under active design or construction in the United States with a total estimated cost of $1,361 million compared with 66 reactors with an estimated cost of $1,325 million at mid-1960. These estimates are based on quarterly surveys conducted by the Commission. The surveys cover all civilian, Army and Navy land-based plants (other than those sold abroad) and plants in the Maritime Program.[5] Costs incurred for these reactors during the fiscal year ended June 30, 1961, totalled $335 million, an increase of about 15 percent above the $289 million of costs incurred in the fiscal year ended June 30, 1960.[6]

The backlog of costs associated with these projects and to be incurred after June 30, 1961, was estimated at $533 million, compared with the $716 million backlog estimated at June 30, 1960.[7] This reduction reflects substantial progress toward the completion of civilian power prototypes and experiments coupled with the limited number of new starts in this category during the intervening year. Civilian power prototypes and experiments account for more than half of the total amounts reported for all reactors covered.

[5] Reactors included in these totals are listed in Appendix 11.

[6] Dollar amounts used are for complete reactor projects including, for example, reactor components and construction, research and development on each specific project, waiver of use charges, non-nuclear portions of central station electric power plants, land for sites and training of operators. An exception is the NS *Savannah* on which only the nuclear plant costs are included.

[7] See pp. 14–15, Annual Report to Congress (January–December 1960).

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TABLE 6.—DOMEST

All Projects
Civilian Reactor Projects
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Civilian testing
Civilian research
Merchant ship propulsion
Military Reactor Projects (exclu
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Military testing and research
Materials Production Reactors

Of the 66 reactors under active design or construction on June 30, 1960, builders had completed 16 at an estimated cost of $142 million by the end of the year. Two of the 16 were civilian power prototypes or experiments, one was a military prototype, two were for civilian testing, one was for military testing, and ten were for civilian research. Two projects—a cooperative power project in Florida and a military testing reactor in Idaho—were discontinued during the year.

The 65 reactors under active design or construction as of June 30, 1961, included 17 new reactors started during the year with a total estimated cost of $178 million. Four of these were civilian power prototypes or experiments, two were military prototypes, two were for civilian testing, two were for military testing, and seven were for civilian research.

Reactor projects included in Table 6 through 9 account for about 40 percent of the total for all reactor work. The survey excludes reactors for actual naval propulsion (but includes Navy land-based prototypes) and excludes reactors for aircraft or space applications. The dollar amounts reported in the survey are limited to costs directly associated with specific reactor projects and exclude costs for general reactor research and development purposes. The general research and development costs and costs associated with naval propulsion, aircraft and space reactors are shown in Table 10 which indicates a total for all reactor work for the year ended June 30, 1961, of $792 million, an increase of about 10 percent over the $715 million for the fiscal year ended June 30, 1960.

TABLE 6.—DOMESTIC REACTOR PROJECTS UNDER DESIGN OR CONSTRUCTION

	At June 30, 1960		At June 30, 1961	
	Number of projects	Total estimated costs	Number of projects	Total estimated costs
		(*Millions*)		(*Millions*)
All Projects	66	$1,328.3	65	$1,360.7
Civilian Reactor Projects	54	1,013.8	52	955.8
Power prototypes and experiments	23	858.4	24	754.4
Civilian testing	7	76.1	7	113.8
Civilian research	23	50.3	20	59.3
Merchant ship propulsion	1	29.0	1	28.3
Military Reactor Projects (excluding naval projects)	11	137.6	12	222.0
Military prototypes, experiments, and field plants	5	107.6	6	193.5
Military testing and research	6	30.0	6	28.5
Materials Production Reactors	1	176.9	1	182.9

TABLE 7.—COSTS INCURRED DURING FISCAL YEARS 1960–1961

	Costs incurred, fiscal year 1960	Costs incurred, fiscal year 1961
	(*Millions*)	(*Millions*)
All Projects	$289.0	$334.8
Civilian Reactor Projects	224.2	222.3
Power prototypes and experiments	188.6	196.5
Civilian testing	20.7	19.1
Civilian research	8.8	9.6
Merchant ship propulsion	6.1	6.9
Military Reactor Projects (excluding naval projects)	48.4	54.5
Military prototypes, experiments, and field plants	45.6	50.4
Military testing and research	2.8	4.1
Materials Production Reactors	16.4	58.0

TABLE 8.—COSTS AND ESTIMATES BY SOURCE OF FUNDS

	Costs incurred fiscal year 1961	Projects active as of June 30, 1961		
		Total estimated costs of projects	Cumulative costs incurred thru June 30, 1961	Estimated costs to be incurred after June 30, 1961
	(*Millions*)	(*Millions*)	(*Millions*)	(*Millions*)
All Projects	$334.8	$1,360.7	$828.1	[illegible]
Source of Funds:				
Federal Government	237.6	943.2	548.9	[illegible]
Atomic Energy Commission [a]	223.6	871.2	501.2	[illegible]
Department of Defense	12.0	46.3	32.1	[illegible]
Other Federal Agencies	2.0	25.7	15.6	[illegible]
Industry and Others	97.2	417.5	279.2	[illegible]
Privately owned utilities	82.6	355.8	244.9	[illegible]
Publicly owned utilities	8.2	37.7	25.1	[illegible]
Manufacturers and universities	6.4	24.0	9.2	[illegible]

[a] The Commission incurred costs of $437.3 million during fiscal year 1961 in its reactor development program for reactor research and development. Of this total, only $76.3 million related directly to projects included here. Commission costs include depreciation and fuel consumed.

TABLE 9.—COST

Totals

Types of Expense:
Plant and equipment
Research and developmen
Fuel fabrication
Land and land rights
Training
Use charges waived

TABLE 10.—TOTAL

Total of projects included in ta
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Other military research and de
Space applications (ROVER a
Other AEC civilian nuclear po
All other AEC reactor develop
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TABLE 9.—COSTS AND ESTIMATES BY TYPES OF EXPENSE

	Costs incurred fiscal year 1961	Total estimated costs of projects	Cumulative costs incurred thru June 30, 1961	Estimated costs to be incurred after June 30, 1961
	(*Millions*)	(*Millions*)	(*Millions*)	(*Millions*)
Totals	$334.8	$1,360.7	$828.1	$532.6
Types of Expense:				
Plant and equipment	236.4	913.4	526.3	387.1
Research and development	76.9	350.6	263.5	87.1
Fuel fabrication	13.0	59.7	24.5	35.2
Land and land rights	.2	3.4	2.6	.8
Training	6.6	21.4	8.9	12.5
Use charges waived	1.7	12.2	2.3	9.9

TABLE 10.—TOTAL ESTIMATED COSTS FOR ALL REACTOR WORK

	Fiscal year 1960	Fiscal year 1961
	(*Millions*)	(*Millions*)
Total of projects included in tables 6 through 9	$289.0	$334.8
Naval reactors (research and development, nuclear portion of propulsion plants, and propulsion plant fuel)	144.1	149.7
Other military research and development (Army, Aircraft, and Pluto)	104.4	106.6
Space applications (ROVER and SNAP)	32.3	56.0
Other AEC civilian nuclear power research and development	63.5	59.3
All other AEC reactor development work (including nuclear technology and reactor safety)	81.4	85.6
Total, all reactor work	714.7	792.0

IMPACT OF SL-1 ACCIDENT

The nuclear accident at the Stationary Low Power Plant No. 1 (SL-1) at the National Reactor Testing Station, Idaho, on January 1961, had no major direct impact on the nation's over-all nuclear reactor program. It did bring about, however, a general tightening of some of the safety procedures under which the program operates. (See Military Reactor Section Part 2, "Nuclear Power Programs," for discussion of the accident and some of the investigative findings.)

Survey of Reactor Operations

Immediately after the reactor accident, the first such fatal accident in Commission history, questionnaires were sent to the operators of Commission-owned or Commission-licensed reactors, asking for information regarding performance of these facilities and safety

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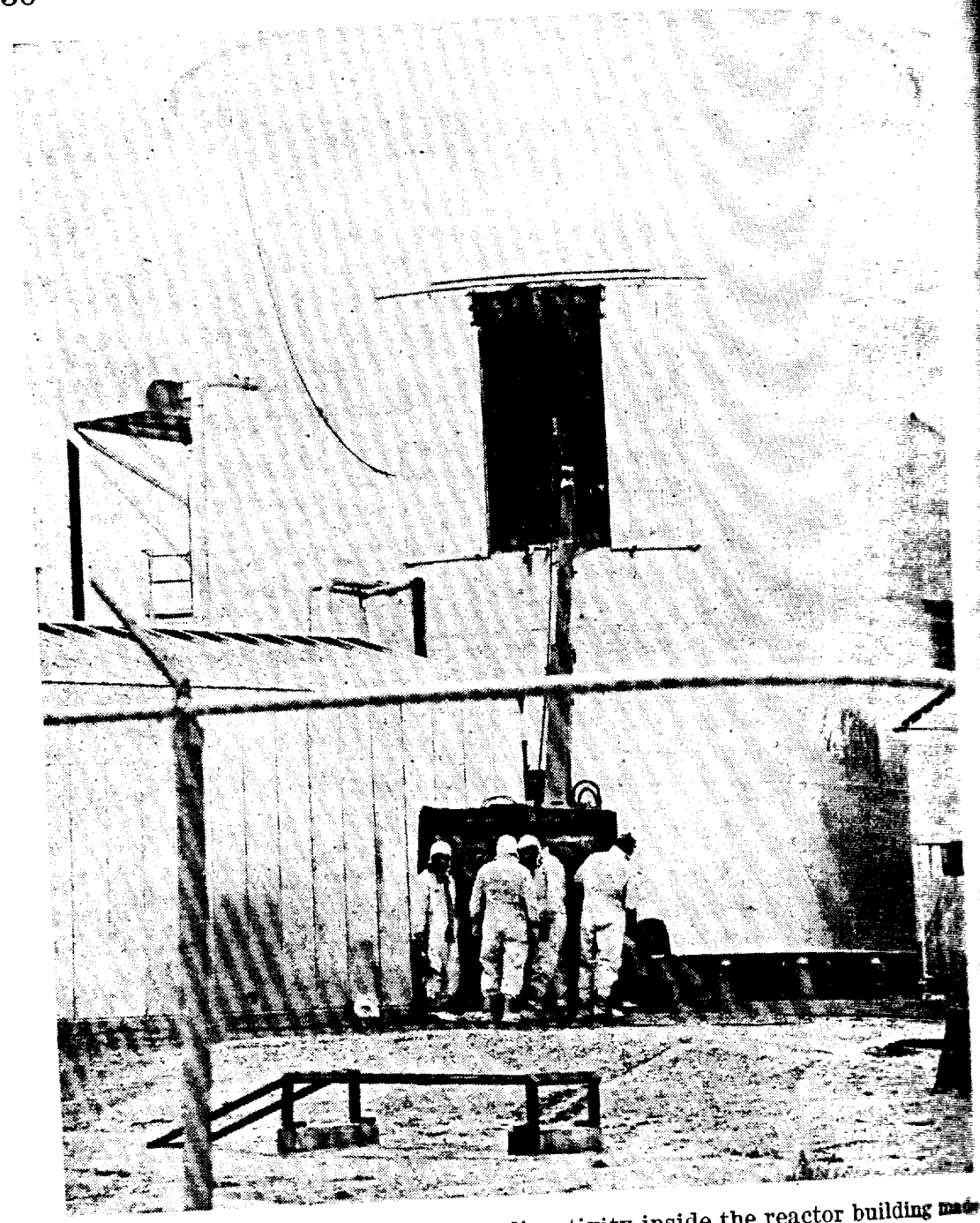

Accident Probe. The high level of radioactivity inside the reactor building made it necessary for investigation of the Stationary Low Power Plant No. 1 (SL-1) accident to be conducted by remote means. Photo shows a "cherry picker" crane being used from outside the containment shell to lower lights and a movie camera into the reactor area a few days after the accident, which occurred on January 3, 1961. Although constructed of light gauge steel, the reactor's containment shell effectively prevented the large amount of radioactivity to escape to the atmosphere. As a safety precaution, the photographic crew worked behind a lead shield and wore U.S. Army "gas masks" to prevent inhalation of radioactive dust. At year's end, the containment shell had been partially disassembled so the reactor core could be removed for minute examination to determine the exact cause of the accident.

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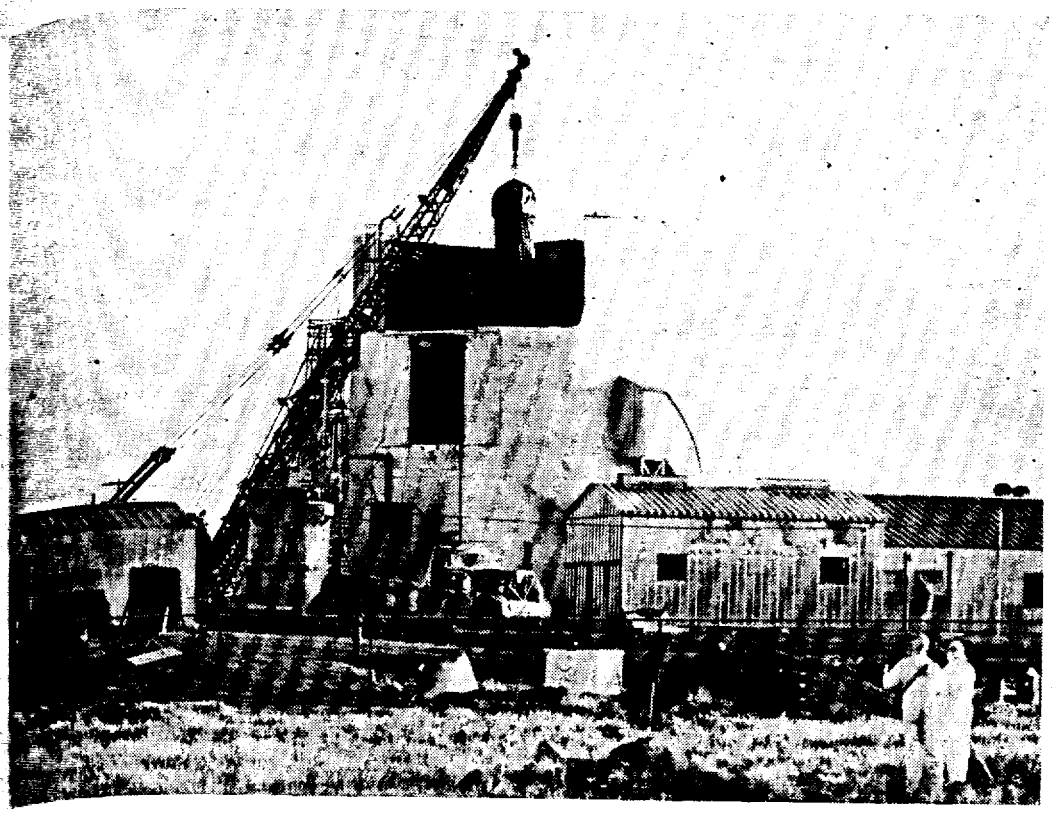
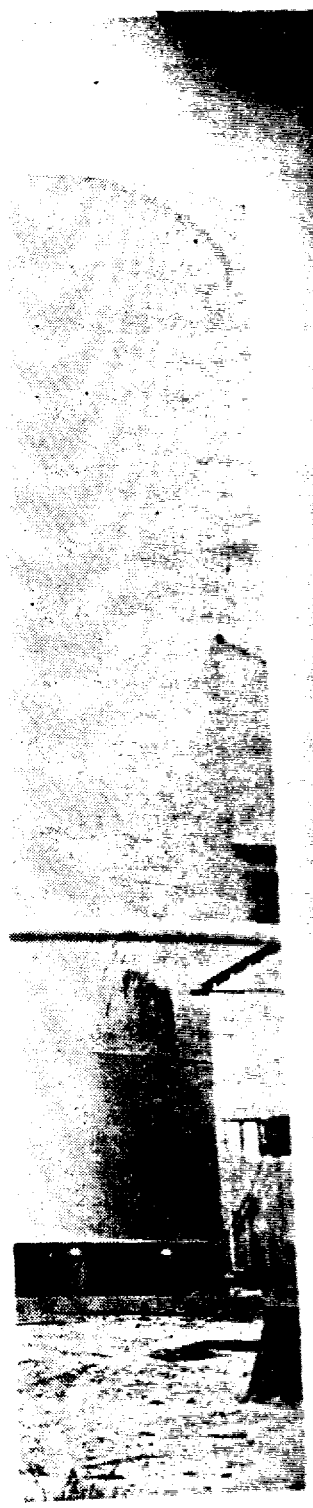


SL-1 Removal. Photo shows the 13-ton pressure vessel and core of the SL–1 reactor being removed from the containment shell on November 29—10 months and 26 days after the accident. In order to make the removal possible, the top and part of one side of the containment building had to be dismantled. As the still highly radioactive reactor vessel was lifted from the floor of the building it was pulled into a plastic bag to minimize the spreading of airborne contamination outside the building. It was lowered into a plastic-covered concrete cask (shown on truck in foreground) and transported 40 miles to hot cell facilities for disassembly and examination which may lead to a determination of what caused the accident. Despite the lapse of time since the accident, and the thickness of the concrete cask, the radioactivity level at the surface of the cask was 30–50 milliroentgens per hour during the four-hour trip. Immediately behind cab of truck is a simulated reactor vessel of precast concrete pipe which was used during dress rehearsals for the actual removal.



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practices and controls in use. The object of the survey was to obtain a comprehensive and current picture of certain aspects of reactor operations and safety procedures as well as to make sure that all necessary safety precautions were being taken during periods of reactor maintenance. (The SL–1 accident occurred while the reactor was shut down for maintenance work.)

Modifications of Licenses

As a step toward further assuring the identification of potentially unsafe operating conditions noted during the operation of nuclear

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research and power reactors, the Commission began modifying some licenses, especially those for research facilities.

The modification, in the form of an amendment to the license, (*1*) adds procedures to be followed with respect to operations when the reactor is shut down and when a change in core reactivity might be involved; and (*2*) requires the reporting to the Commission of any deviations from the predicted operating characteristics of the reactor.

Personnel Procedures Survey

The Commission also undertook a survey among its licensees who are operating nuclear reactors and critical facilities to determine the type and size of operating, maintenance, and health physics staffs in actual use at each facility.

The purpose was to obtain comprehensive information on the current staffing of licensed reactor operations. The information is being used for development of revised criteria for the minimum size of operating staffs for the various types of reactors and critical experiment facilities.

Safety Staffs in Field Offices

The Commission also took steps to assure that its field Operations Offices are more knowledgeable of the conditions of reactors operating under their jurisdiction through the establishment of reactor safety inspection staffs at the Operations Office level.

The safety staffs are made up of technically qualified personnel responsible for making independent inspections of reactors and contractor-operators under the jurisdiction of the pertinent Operations Office.

Contract Modifications

The Commission's contractor-operators have always been responsible for safe operation of reactors in their charge, and these responsibilities were included in the contracts under generalized terms. In order to delineate these responsibilities more specifically, the Commission is incorporating into its reactor operating contracts provisions which spell out in detail the various aspects of health and safety precautions contractors are required to take. (See Contracting Policy section in Part 3, "Major Activities," of this report.)

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Investigation Results

The exact cause of the accident has still not been determined, although minute physical examination of the reactor core may lead to such a determination now that it has been removed for disassembly. Because of the high level of radiation (as much as 1,000 roentgens per hour) surrounding the reactor core, it could not be removed from the site until the end of November. Prior to its removal, examinations were conducted by remote means, such as movies or closed circuit television, with a lead-shielded camera lowered into the reactor area by crane.

One reassuring factor regarding over-all reactor safety was the finding that the nature of the radioactive fission products, fuel fragments, and water and steam drenched debris violently ejected from the ruptured control rod ports in the top of the reactor vessel at the time of the accident was such that a major portion was retained within the building, although this was constructed of light gauge steel and was not designed for "tight" containment.

PROGRAMS IN SUPPORT OF INDUSTRY

In carrying out its statutory responsibilities to encourage the participation of United States industry, educational and scientific institutions, and other organizations in the over-all aspects of the atomic energy program, the Commission took a number of actions that enhanced the industrial program while, at the same time, the actions assured that any changes brought about would not create undue hazards to the public health and welfare and would not be adverse to the national defense and security.

Commission Actions During 1961 Having a Bearing on Industry

Industrial Participation

On May 1, 1961, the Commission established an Office (now Division) of Industrial Participation which reports directly to the General Manager. The new division has an over-all responsibility for promoting industrial participation in all aspects of the atomic energy program and replaces other sub-divisional organizations within the Commission framework which were responsible for industrial participation in specific areas.

The new division will:

Provide a focal point, within the Commission, at which industry may obtain information on opportunities for private participation

and investment in the development and utilization of atomic energy for civilian purposes and for support of Government programs.

2. Study industrial-type activities now being, or to be, performed by the Commission's operating contractors which might lend themselves to performance by private industry. It will recommend to the Commission policies, plans, and programs for the transfer of such activities to industry when warranted and with due regard for the interest of the Government, and which will support progress toward the objectives of the Commission's over-all program.
3. Appraise and report on the implementation of Commission policies relating to utilization of private industrial capabilities.

Policies on Industrial Participation

During January 1961, in a letter to the Committee on Commercial Uses of Atomic Energy, Chamber of Commerce of the United States, the Commission placed renewed emphasis [8] on its established policy of procuring goods and services from private industry whenever it is practicable and reasonable to do so. In part, the letter read: "* * * It is Commission policy to implement the free enterprise provisions of the Atomic Energy Act of 1954 and the Bureau of the Budget Bulletin 60–2 * * * The staff has tried hard to * * * (make) known the needs of our facilities which private industry may be interested in supplying. The Commission has issued instructions to the field to review all work projects and determine those which might be done by private industry. Before we take on any new activities we insist that our people investigate commercial sources or applications * * * We will continue to emphasize this approach in the future * * *."

This basic policy has been put into effect over the years in a number of ways. For instance:

a. Commission facilities are used to provide industry with materials that are unique or of major importance for atomic energy applications only so long as industry itself cannot perform these functions on a reasonably competitive basis.

b. The facilities and skills of private industry are, and will be, employed when they are adequate to carry out specific activities in the military and peaceful applications of atomic energy at the rate required to attain our national objectives.

c. The Commission establishes charges for materials and services so as not to discourage persons outside the Commission from developing adequate sources for materials and services for which the Commission's facilities are now the sole or main source.

[8] See pp. 475–499, Annual Report to Congress (January–December 1960).

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d. If, and when, outside sources are, or can be, developed, it is the intention of the Commission to avoid competing with them, provided that the prices or charges of the outside sources are at levels which will not discourage research, development, and commercial production in the field of atomic energy.

e. To the greatest extent practicable, the Commission's capacity is reduced, and conceivably eliminated in some instances, as adequate and reasonably priced outside sources become available for both private and Governmental needs.

f. The Commission encourages private industry to build and operate plants for the chemical processing of irradiated fuel elements from research and power reactors. The Commission will provide technical information for these plants and, for agreed periods of time, limited quantities of Commission-irradiated fuel which can be diverted for processing in private facilities to provide a base load.

g. Regional radioactive waste disposal sites for the use of private industry for permanent disposal of low-level, packaged radioactive waste materials are to be established, as needed, on State or Federal Government-owned land.

h. The Commission no longer furnishes irradiation services to commercial users in the Materials Testing Reactor, Engineering Test Reactor, and other Commission reactors since privately owned test reactors are now in operation.

i. The Commission seeks to favor firms not currently under contract to the Commission in the selection of new operating contractors as a means of broadening the industrial base of the atomic energy program.

j. The Commission promotes the participation of industry in the nuclear field on an increasing scale and transfers to industry, as industry indicates its capability to perform, operations or functions now being performed in Government facilities.

Withdrawal From Services

During 1961, the Commission withdrew from three more services since private industry had demonstrated a capability for performing them. These were: the furnishing of radioisotopes at discount prices to non-profit institutions for research use, the production of cobalt and the production of plutonium-beryllium neutron sources.

Research radioisotopes. Effective July 1, the Commission terminated a 13-year-old program of providing radioisotopes made in its facilities at a discount for domestic research in biology, medicine, and agriculture because private industry had shown it could now provide these materials at a competitive cost.

During the past six years the program has helped achieve a reasonable level of success in introducing and encouraging the use of radioactive tracer technology as a basic research tool in the medical, biological, and agricultural sciences. During the year previous to the discontinuation, some 240 discount certificates were issued to approximately the same number of universities, colleges, hospitals, and state and private non-profit research institutions.

The Commission will continue to encourage the use of radioisotopes in research through other programs in the most effective ways available to it. For example, the radioisotope equipment grant program fosters the use of isotopes in educational institutions at undergraduate and medical schools. This program, in the life sciences alone amounts to $1,000,000 annually. In addition, the Commission provides substantial support to research projects, through contracts, at universities and other scientific institutions throughout the country.

A large number of companies purchase bulk quantities of radioisotopes from the Commission and then package them for commercial sale, and four firms use privately owned reactors for the production of radioisotopes. Radioisotopes not available through these sources, either by type or specific activity, will be produced in Commission facilities for private use as necessary.

Cobalt 60. On May 2, the Commission announced its withdrawal from the routine production and distribution of cobalt 60, effective as of that date, since the radioisotope can be produced by private industry in sufficient quantities to meet ordinary demands. Both the General Electric Co. and Westinghouse Electric Corp. had previously announced that they would use their test reactors at Vallecitos, Calif., and Waltz Mill, Pa., respectively, for production of cobalt 60 for radiography, teletherapy, and other common applications. However, because of the limited quantities that could be produced in the two test reactors, the Commission will continue production of cobalt 60 to meet certain industrial requirements.

The Commission will continue to provide cobalt 60 (up to a specific activity of 30 curies per gram) only in quantities greater than 100,000 curies to encourage development of ionizing radiation as a major processing tool. This will be done on a custom order basis where the customer is prepared to accept the material in a single shipment. This material is priced at $1 per curie. The price schedule for other than 100,000 curie quantities of cobalt 60, established September 9, 1960, is no longer in effect for cobalt 60 supplied from Commission facilities.

The Commission will consider providing cobalt 60 of the type and in the quantity employed in radiography, teletherapy, and other commercial applications only when it is demonstrated by the purchaser

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Specific activity (curi	
1–25	
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56–70	
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	5001–25,000 curies
	25,001–100,000 curies

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that the supply of such material from private sources is not reasonably adequate. Under these circumstances the Commission's charges are:

Specific activity (curies per gram)	*List price per curie*
1–25	$2.00
26–40	3.00
41–55	4.00
56–70	6.00

Discounts

0–5000 curies	List price
5001–25,000 curies	List price less 15 percent
25,001–100,000 curies	List price less 30 percent

The above list does not include handling or service charges.

These prices are substantially the same as those announced on September 9, 1960, except that the discounts on larger purchases are less—list price less 15 percent, rather than 25 percent, on 5,001 to 25,000 curies, and list price less 30 percent, rather than 50 percent, on 25,001 to 100,000 curies.

Currently, there are ten major encapsulators of cobalt 60 sources greater than 100 curies in the nation.

Neutron Sources. On November 1, the Commission announced its withdrawal as a supplier of plutonium-beryllium (Pu-Be) neutron sources since a commercial supplier had demonstrated its ability to produce neutron sources comparable in design and prices with those fabricated by the Commission. In addition, a second firm has signified its intention of entering the Pu-Be neutron source market.

Previously, the Commission's Mound Laboratory, Miamisburg, Ohio, had been the sole supplier of Pu-Be neutron sources in the United States. The laboratory is operated for the Commission by Monsanto Research Corp. Because of other work assignments at Mound, the withdrawal had no effect upon the employment level or the use of equipment at the facility.

The neutron sources are used in geological oil surveys, in medical and biological studies of the effects of radiation, in basic physical studies, in the initiation of a chain reaction when nuclear reactors are started up, and in running subcritical reactors, which require an extra source of neutrons to maintain the chain reaction.

Nuclear Materials and Equipment Corp. was granted a Commission license for the fabrication of the sources during late 1960 and at present is the only commercial supplier of the devices. Monsanto Research Corp. has applied for a license and, subject to Commission action on its application, expects to produce the sources in its commercial facility at Dayton, Ohio, early in 1962.

In its announcement of withdrawal, the Commission gave notice that all future requests for Pu-Be neutron sources from other Government agencies and private industry should be directed to the

commercial producers. However, in order to assure an orderly transfer of Pu-Be source production from the Commission facility to private industry, Mound Laboratory continued to supply a limited number of sources. At the end of the year, all requirements were being obtained from commercial suppliers except sources (*1*) approved by the Commission prior to November 1 for loan to educational institutions under the Educational Assistance Program; and (*2*) sources for certain Naval applications.

Reduction in Enriched Uranium Charges

Nuclear power costs in the United States were lowered somewhat by the Commission decision to reduce its base charges for enriched and depleted uranium, effective July 1, 1961. At the same time, an increase was made in the rate-of-use charge assessed to lessees of special nuclear material, but the estimated net effect of the two changes will be a reduction of as much as one-half mill per kilowatt hour in the fuel cycle costs of water reactors. The changes apply to material leased or sold in the future under domestic and foreign arrangements and also to material under certain existing foreign arrangements.

The reduction in base charges varies from 20 percent for highly enriched uranium to 34 percent for uranium containing one percent uranium 235. The reduction in base charges approaches 40 percent as the uranium 235 assay nears that of natural uranium and ranges up to 63 percent for depleted uranium.

The reduction in base charges was made possible by decreased costs of natural uranium. The new charges correspond to a price of $8 per pound of uranium oxide (U_3O_8) in natural-uranium concentrates, which is the price established by the Commission under its domestic purchase program for the period from April 1, 1962, to December 31, 1966. The component of the base charges, representing the work of separating uranium isotopes, remains the same.

The use-charge rate was increased from the previous 4 percent to 4.75 percent to take account of increases in the cost of money to the United States Government since the rate was first established in 1954. Administrative costs to the Commission of leasing material are also included in the 4.75 percent.

The revision of the schedule of charges for enriched and depleted uranium (see Table 11) does not affect present commitments by the Commission regarding prices for plutonium and uranium 233 through fiscal year 1963. There are no Commission commitments for prices to be paid for plutonium and uranium 233 after June 30, 1963, although the Atomic Energy Act of 1954, as amended, requires the Commission to receive special nuclear material produced by licensees and to pay a fair price for such deliveries.

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U-235 assay in w

Enriched Uranium:
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TABLE 11.—EXAMPLES OF BASE CHARGES FOR ENRICHED AND DEPLETED URANIUM AS URANIUM HEXAFLUORIDE

U-235 assay in weight percent	New charges		Previous charges—dollars per gram of contained U-235	Percent reduction
	Dollars per kilogram of contained uranium	Dollars per gram of contained U-235		
	(*Official Base Charges*)			
Enriched Uranium:				
90	12,285.00	13.65	17.07	20
20	2,547.00	12.74	16.12	21
10	1,195.50	11.95	15.29	22
5	535.50	10.71	13.96	23
3	281.20	9.37	12.52	25
2	160.00	8.00	11.00	27
1.5	102.60	6.84	9.70	29
1.0	49.90	4.99	7.58	34
Depleted Uranium:				
0.7	22.60	3.23	5.45	41
0.6	14.80	2.47	4.48	45
0.5	8.05	1.61	3.33	51
0.4 [a]	3.00	0.75	2.04	63

[a] If a user specifies a U-235 assay between 0.4 and 0.22 weight percent, the charge will be $3 per kilogram of contained uranium. However, if the U-235 assay is not specified by the user, the Commission will supply uranium having a U-235 assay to be determined by the Commission in the range below 0.4 percent and will charge $2.50 per kilogram of uranium.

Commercial Conversion of UF_6

Again in 1961, as in the two prior years, about 95 percent of enriched uranium supplied industry by the Commission was in the form of uranium hexafluoride (UF_6). This is a good indication of the extent to which commercial sources are depended upon for the conversion of uranium hexafluoride to materials suitable for intended end uses, especially reactor fuels.

In the six-year period, 1956–61, this form of industrial activity has very nearly made a complete reversal in the type of UF_6 supplied to industry. While all of the enriched uranium furnished by the Commission in 1956 required processing beyond the uranium hexafluoride stage in the Commission's facilities, today some 95 percent is processed beyond this stage in commercial plants. The figures below show this change.

ENRICHED URANIUM FURNISHED TO INDUSTRY

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

[a] Primarily for AEC programs.

Orders for Fuel from Industry

The total dollar value of orders placed by the Commission and its principal contractors with commercial sources for the conversion of uranium hexafluoride to materials suitable for fuel elements, and for fabrication of fuel elements, showed a marked decrease for fiscal year 1961 over the previous year.

The decrease, as shown in the figures below, was in the need for fuel elements for naval use. However, it is anticipated that naval use orders for fiscal year 1962 may approach twice the fiscal year 1961 level. The dollar volume for fuel materials and fuel elements for other Commission uses continued to show a steady gain.

The comparisons for the past three fiscal years:

AEC ORDERS FOR NUCLEAR FUEL FROM COMMERCIAL SUPPLIERS

	Fiscal year (millions of dollars)		
	1959	1960	1961
Orders placed for:			
Naval reactors	38.6	48.6	[illegible]
All other uses	2.8	3.8	[illegible]
Total	41.4	52.4	[illegible]

Processing Costs for Small Batches

During May, the Commission published a change in costs for chemical reprocessing and conversion of small batches of spent fuels from research reactors. The new charge for chemical processing only of enriched uranium (other than uranium 233)-aluminum alloy spent fuels will be $145 per kilogram of the total weight of uranium and aluminum metal contained in a processing batch, provided the processing batch contains less than 400 kilograms and the uranium 235 content does not exceed 10 percent of the total weight of the uranium and aluminum metal.

The new charge will be used through June 30, 1967, and will require the licensee to accept the Commission's determination of the amount of uranium contained in a processing batch. The licensee is required to waive the right to have isolated batches processed but saves on the "cleanout charge" made for isolated batches. Under the new system the cost for processing a 100 kilogram batch is about $14,000 as against the former cost of $37,000.

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[10] See pp. 63–64, 299–

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Nonproduction Fuel Processing

The Commission's responsibility to receive irradiated fuels from research, test, power and propulsion reactors and to make financial settlement for the contained fuel values in accordance with existing notices[9] has been consolidated at the Commission's Savannah River and Idaho Offices. Idaho is responsible for the receipt of all highly enriched fuels and Savannah River is responsible for receiving all other nonproduction fuels. Previously, in October 1959,[10] the Commission had announced that its facilities at Oak Ridge and Hanford would also be used in the reprocessing of spent fuels from private and foreign reactors.

Three contracts were executed at Idaho during 1961—two with General Electric for fuels from its Vallecitos Boiling Water Reactor and Test Reactor and the other with Westinghouse for its test reactor fuels. Although no contracts have been executed for the receipt of fuels at Savannah River, negotiations between that office and several power reactor operators are currently underway.

Private Processing Plant

The Commission is continuing to defer expansion of its reprocessing facilities in order to give private industry a chance to undertake this work.

The Industrial Reprocessing Group (IRG), composed of the Davison Chemical Division of W. R. Grace & Co. and a number of utilities, continued its studies, during 1961, on the possible construction and operation of a privately owned plant for reprocessing irradiated fuel. IRG has determined that the plant is technically feasible and expects that current studies will lead to acceptable solutions of remaining problems. No date or location has been established for construction of the plant.

Although the Commission has announced that it will provide for reprocessing services, suitable private facilities are considered a key requirement for a self-sufficient nuclear power industry. One of the basic problems of a private plant of this type is an adequate supply of spent fuels from private reactors to keep the plant in regular operation. The Commission anticipates that it could divert sufficient spent fuel from its own reprocessing operations to form a base load for a privately owned plant until the number of privately owned reactors adequate to supply this base load.

[9] As published in the Federal Register (FR-1591) of December 12, 1957.
[10] See pp. 63–64, 299–300, Annual Report to Congress (January–December 1959).

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Uranium Allocation Increased

The President, on September 26, announced that under Section 41b of the Atomic Energy Act of 1954, as amended, the amount of enriched uranium to be made available for peaceful uses domestically and abroad was being increased by 65,000 kilograms of contained uranium 235. The increase put the total allotment at 165,000 kilograms. Of this total, 100,000 kilograms are destined for distribution within the United States and 65,000 kilograms for distribution to other countries. The increase was recommended by the Commission to cover existing commitments and those expected to be made during the next few years under domestic licenses and foreign agreements, including material for research, test, and power reactors.

The program was initiated on December 8, 1953, by President Eisenhower during a speech at the United Nations. At that time he made an allotment of 200 kilograms to the "Atoms for Peace" program. On February 22, 1956, an allotment of 40,000 kilograms was announced.[11] The last previous Presidential determination of enriched uranium allotments was announced on July 3, 1957, when an allotment of 59,800 kilograms brought the total uranium 235 available to 100,000 kilograms.

Enriched uranium for peaceful purposes is distributed abroad only under agreements for cooperation in the civil uses of atomic energy between the United States and a foreign country or international organization, such as the International Atomic Energy Agency (IAEA). All such agreements for cooperation contain a guaranty by the cooperating country that the material supplied will be used exclusively for peaceful purposes. Where appropriate, safeguard provisions allowing inspection of materials, facilities, and records by United States or international inspectors are also included in the agreement.

Appendix 15 includes President Kennedy's announcement and Chairman Glenn T. Seaborg's discussion of the increased allotment.

Fission Product Availability

During May, the Commission announced it was taking steps to make larger quantities of useful fission products[12] available to industry for final processing and fabrication into nuclear "batteries" and other devices. Chief among the fission products to be made available are strontium 90, cesium 137, and cerium 144. These products are

[11] See pp. 252–253, 20th Semiannual Report to Congress (January–June 1956).

[12] Fission products are radioactive isotopes found in the wastes generated in reprocessing "spent" nuclear reactor fuel for recovery of the unused uranium and the plutonium that has been created by the fissioning process.

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presently available from the Commission's Oak Ridge National Laboratory (ORNL) in limited quantities. To supply the large quantities expected to be needed in the future, the Commission is setting up recovery facilities as part of its Hanford, Wash., operations.[13] ORNL will continue to operate its fission product recovery plant to meet specialized requirements.

Present plans would enable the Commission to begin supplying fission products in refined, chemical form in megacurie quantities about mid-1963. The isolated fission product compounds will be offered for sale to private companies interested in final processing of the material, fabricating it into finished products, and developing useful applications.

The Commission had previously considered formally inviting private industry to undertake the recovery operation (see below). However, indications are that at present it would be more feasible for the Commission to recover the fission products and offer them for sale to industry for final processing, fabricating, and marketing.

Currently, the most active interest in fission products centers in the beta-emitting strontium 90 as a long-lasting source of heat energy that can be converted into low-wattage electric power as a substitute for ordinary storage batteries in remote locations for weather stations, navigational lights, sonobuoys (underwater listening devices), and similar devices. Strontium 90 is currently being used also in thickness gauges. Other applications of strontium 90 may include static eliminators, and radiation sources designed to induce certain chemical reactions such as polymerization—the linking together of individual molecules of a compound to produce larger molecules in order to change the physical properties of the compound.

The principal interest in cesium 137, a beta and gamma emitter, is for application in gamma irradiation devices such as teletherapy, radiographic, and research units. Pasteurization of food and sterilization of medical supplies are additional possible applications. Cesium 137 may also find applications in radiation chemistry and in nuclear batteries.

Cerium 144 may also be used in nuclear batteries as a power source. It is a relatively abundant fission product, but has disadvantages of a shorter half-life (285 days) and a high gamma output, which requires heavy shielding. Other fission products to be recovered, if sufficient demand develops, are zirconium 95 and promethium 147.

Private recovery of fission products. Before authorizing the fission product recovery operations at the Hanford plant, the Commission explored the extent of potential private participation in the recovery

[13] See Production section in Part 3, "Major Activities," of this report.

of fission products from waste streams. It was determined that the Commission could not make the long-term guarantees required by the informal private participation proposals suggested at that time.

Although it was decided not to invite industry formally to undertake, on a private basis, the recovery of usable fission products at this time, the Commission is continuing to study the possibility of increased industrial participation in the Hanford program for the extraction of fission products from the waste streams being generated by the production reactors.

To assist in the study, the services of a group of five industrial representatives, selected by the Manufacturing Chemists' Association, has been obtained. One of the representatives is from The Martin Co. (now Martin-Marietta Corp.) which, during 1960, indicated an interest in undertaking a privately owned fission product extraction project.

Private Ownership of Special Nuclear Material

When the new schedule of Commission charges for enriched and depleted uranium was announced on May 29, 1961 (see above), the Commission stated that it had under consideration the desirability of recommending amendments to the Atomic Energy Act to eliminate the statutory requirement for Government ownership of special nuclear material.

In discussions held on the subject particular attention was paid to the primary and essential aspects of maintaining effective international and domestic safeguards against diversion of the nuclear materials from their intended purposes. It is also apparent that Government regulation of special nuclear material within the United States, pursuant to licensing and regulatory procedures under the Atomic Energy Act, would still be necessary if private ownership is permitted.

The Commission is also considering the transition measures that might be necessary over a period of time, if the change were made, in order to avoid an undesirable impact on the progress of the nation's nuclear power program. This impact would be primarily financial and would stem from two sources.

One would be the cost of nuclear fuel inventory, which for privately owned utilities, would be roughly double if the nuclear fuel were purchased rather than being leased at an interest charge of 4¾ percent. For thermal reactors, the increase might range from 0.2 to 0.5 mills per kilowatt-hour, and for a fast reactor it might be as much as from 1 to 2 mills per kilowatt-hour.

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The other source of impact would be the uncertain value of by-product plutonium or uranium 233 if there were no statutory requirement that the Commission own and pay for the plutonium or uranium 233. A market for plutonium at $9.50 per gram of metal, for example, corresponds to a credit of 0.5 to 1.0 mills per kilowatt-hour in typical thermal reactor cases.

To investigate this matter, a Commission staff group was assigned to discuss the subject informally with representatives of industry and the public, giving particular attention to the kind of transition measures which might be necessary to avoid too serious impact on the growing industry. During the summer and fall of 1961, sessions were held with representatives of several utilities now operating or building large nuclear power stations, and with committees of the Atomic Industrial Forum, the Edison Electric Institute, the National Association of Railroad and Utility Commissioners, the American Public Power Association, and the American Federation of Labor and Congress of Industrial Organization. The Atomic Industrial Forum and the Edison Electric Institute set up special groups for further study of, and report upon, the subject.

The comments received and the course of action to be taken are under consideration by the Commission and are being discussed with other agencies of the Government.

Uranium Scrap Recovery

Commercial recovery of uranium from unirradiated scrap produced in Commission operations reached a value of $1,435,645 for the fiscal year ending June 30, 1961. This was more than five times the figure of $275,000 reported for the fiscal year that ended June 30, 1960.

The program was first undertaken during fiscal year 1959 when initial orders, as of June 30, 1959, totaled $116,000. During 1961, there were six firms bidding for this work.[14]

Recovery of Plutonium from Scrap

In mid-1961, the Commission received an expression of interest from the Dow Chemical Co. regarding the commercial recovery of plutonium from non-irradiated scrap generated in the Commission's production-weapons work.

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[14] Davison Chemical Co., Erwin, Tenn.; Englehard Industries, Inc., Baker Platinum Division, Newark, N.J.; Nuclear Materials & Equipment Corp., Apollo, Pa.; United Nuclear Corp., Chemicals Division, Hematite, Mo.; National Lead Co., Albany, N.Y.; Spencer Chemical Co., Kansas City, Mo.

The expression of interest came as a result of a survey, instituted in late 1960 by the Commission's New York Operations Office, to determine industry capability and interest in this type of work. During the survey, five companies with potential capabilities for the scrap recovery operation showed an informal interest in the work.

At the end of 1961, the Commission had the Dow proposal under study and was considering the feasibility of supplementing the very limited quantities of plutonium-bearing scrap currently generated in other nuclear activities with scrap from production-weapons activities. This would be a means of providing an economic base-load level for operation of one or more privately financed plutonium recovery facilities. The Commission foresees that in future years there will be a need for such commercial services to support plutonium-fueled reactors. The recovery of plutonium from scrap on a commercial basis at this time would be an initial step toward fulfilling that future need.

Gas Centrifuge Work Opened to Industry

During April, the Commission amended its regulations to allow private industry to work in classified areas of the gas centrifuge field [15] and to retain the benefits of its work. The gas centrifuge is being developed for the separation of heavy isotopes which can be handled in gaseous form, for example, the separation of uranium 235 from uranium 238 in a system employing gaseous uranium hexafluoride.

Industry has expressed interest in the possible commercial use of the gas centrifuge process to provide fuels for nuclear reactors. Since the process also has a potential use in the production of weapons material, technology on the gas centrifuge is classified.

The Commission amended [16] its regulations, 10 CFR Part 25, to extend its Access Permit program to classified areas of the gas centrifuge field by establishing a new category of information, "Isotope Separation—Gas Centrifuge Method". After appropriate authorization, individuals or firms may obtain access to restricted data of value for private business and research uses. These applicants must meet the Commission's requirements for protecting classified information.

In addition to meeting other conditions of the Commission's Access Permit program, applicants for access to classified data in the gas centrifuge field will be required to demonstrate serious intent to further

[15] See pp. 102–104, 500–504, Annual Report to Congress (January–December 1960).
[16] Published in *Federal Register* of April 20, 1961.

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gas centrifuge development; report results of work to the Commission; allow Commission inspection of the work being done; grant a license to the Government on any patent invention, or discovery conceived during the work and for one year after the permit has terminated; and give the Government the right to use proprietary data developed.

Any permittee desiring to build or operate a gas centrifuge plant must obtain the required licenses under Commission rules and regulations. The granting of an Access Permit imposes no obligation on the Commission to grant any license for a production facility or otherwise facilitate the commercial use or sale of any invention or development which may result from work conducted by industry.

Gas centrifuge contract. The Commission, during September, contracted with AiResearch Manufacturing Division of the Garrett Corp. to conduct research aimed at developing an advanced gas centrifuge for separation of uranium isotopes, as part of the Commission's overall research and development program to further the technology on uranium separation by this method. Under the contract, the company will carry out essentially all of the work in its own facilities.

Currently, the Commission's work in the gas centrifuge program also includes contracts with the University of Virginia for continuing basic research, Yale University for theoretical studies, and Union Carbide Nuclear Co. for performing centrifuge experimental work.

Burial of Low-Level Radioactive Waste

The Commission policy on land burial of low-level packaged radioactive waste continues to limit such burial to Government-owned land (Federal or State). This limitation is to assure adequate protection of the public health and safety throughout the period of any potential hazard. During the year, some sea disposal of wastes continued, but no new authorizations for such operations were issued.

To make land burial service available to the private nuclear industry, the Commission, during 1959, designated the National Reactor Testing Station, Idaho, and Oak Ridge National Laboratory, Tenn., as as interim burial grounds for receipt of such industry-generated wastes. At the same time, it was announced that regional burial sites would be established elsewhere as the need arose.

During fiscal year 1961, the Oak Ridge and Idaho interim burial sites received 65,000 and 10,000 cubic feet, respectively, of low-level packaged radioactive waste from land disposal licensees. These radioactive wastes were contained in 11,500 separate packages and/or

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containers and involved the use of approximately 1.1 acres of burial area. During this same period, Commission-generated wastes buried at these two sites totaled approximately one million cubic feet.

If the growth of the atomic energy industry shows new low-level waste burial sites are needed, the Commission now foresees that State governments may wish to establish and control sites for the benefit and convenience of the nuclear industry. Currently, the State of New York is proposing to establish a burial ground for low-level radioactive waste at its Western New York Nuclear Service Center in Cattaragus County, N.Y.

First license application. Several private organizations have shown an interest in operating a commercial burial facility, but only one has initiated specific arrangements for such an operation. The first license application covering a commercially operated land burial site for radioactive waste was submitted to the Commission in October by Nuclear Engineering Co., a firm heretofore licensed to dispose of low-activity, packaged waste at sea or at Commission-owned and controlled land burial sites.

The license application covers burial of low-level waste at a site near Beatty, Nev., about 100 miles northwest of Las Vegas. The proposed site is owned by the State of Nevada.

The Commission has consulted with the State of Nevada in the review of this application.

Actions Affecting Reactor Program

While the Commission has a statutory responsibility for promoting the use of nuclear reactors in the generation of electric power, it also has a responsibility to insure that such operations are conducted in the public interest with respect to health and safety. During the year, the Commission took several actions having a bearing on public safety. The Commission also adopted several regulations affecting licensed activities and published others as proposed rules for public comment. (See Regulations and Amendments section of Part 4, "Regulatory Activities" of this report.)

Proposed Site Criteria Guide

During February, the Commission published in the *Federal Register*,[17] for public comment, a "Notice of Proposed Guides" containing the criteria the Commission will use for guidance in its evaluation of

[17] February 11, 1961.

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The Commission developed the proposed guides so that industry, State and local officials, and the general public, may become familiar with the factors which are considered by the Commission in judging proposed sites for reactors and with the criteria which guide the Commission in evaluating the suitability of proposed sites. At year's end, comments had been received from numerous industrial groups and individuals including several from foreign countries. The Commission staff is evaluating them in its further study of the proposed guides.

Public Participation in Safety Determinations

During November, the Commission amended its Rules of Practice to require applicants for facility licenses and radioactive waste disposal licenses to serve copies of the applications, and applications for amendments to such licenses, on the officials of the communities in which the facilities will be, or are, located. In the past, information on licensing actions has been routinely supplied to State authorities by the Commission. The new regulation will assure that local authorities are also kept informed.

Public Meetings on Reactors

The Commission also initiated on an experimental basis the practice of holding informal public meetings in the local community prior to the granting of a construction permit or operating license, in order that the public may ask questions regarding the safety of the facility and Commission staff members can describe the regulatory procedure being followed in the particular case. The first such meetings were held at Pleasanton, Calif., on June 19 in connection with the Vallecitos Superheat Reactor; at Gaithersburg, Md., on November 16 concerning the National Bureau of Standards Reactor; and at Delta, Pa., on December 8 in connection with the Peach Bottom Reactor project of the Philadelphia Electric Co. Such public meetings are in addition to the required formal public hearings.

Nuclear Liability Insurance

In late 1960 the Commission completed a re-evaluation of the financial protection (public liability insurance) requirements of its in-

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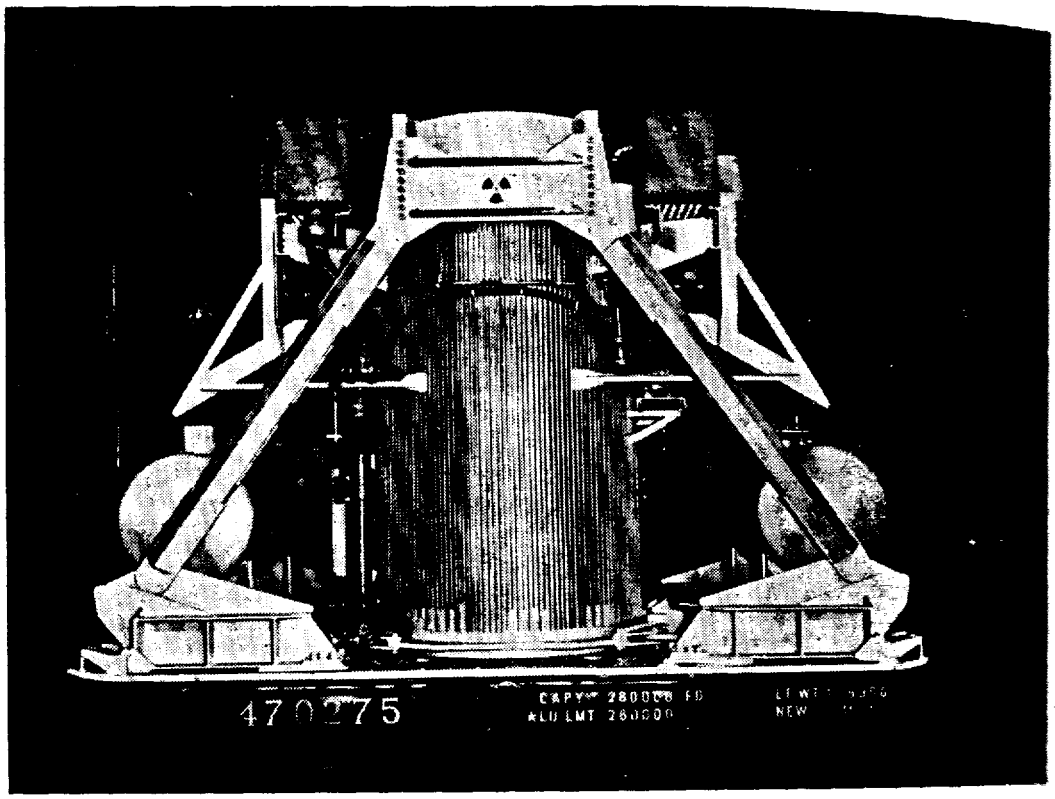
demnity regulations (Part 140). Under the regulations reactor licensees subject to the financial protection requirements are required to furnish proof of financial protection in amounts ranging from prescribed minimums for the smallest reactors to a maximum of $60 million for power reactors licensed to operate at power levels of 100 electrical megawatts or more. For other reactors the financial protection requirement is determined by a formula which includes, as basic elements, power level and location in terms of population.

As a result of its re-evaluation the Commission on February 17, 1961, amended its regulations in Part 140 to revise the formula by extending the range of the location factor from 1 to 1.5 to a range of 1 to 2. The revision of the range results in somewhat higher financial protection requirements for reactors in more densely populated areas. In other respects the financial protection requirements of the regulations are unchanged.



Spent Fuel Transport. Typical of the special casks being built for transportation of highly irradiated spent reactor fuel elements is the above 125-ton unit mounted on a depressed-center railroad car. The shipping cask was designed and fabricated under Commission contract by Knapp Mills, Inc., for use in transporting spent fuel elements from the Navy's nuclear fleet. A one-foot thick "ferro-nicrolum" shield wall of the cask body safely prevents escape of gamma radiation emanating from the spent fuel.

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Transportation of Radioactive Materials

Transportation Meetings

One of the more perplexing problems in the atomic industry has been the reluctance of transportation agencies to accept loads of radioactive materials, not only for shipment within the continental United States but also for overseas destinations.

For several years, the Commission has had a program to provide domestic carriers (primarily rail and motor) with information on the transportation characteristics of atomic energy materials and products. An example of such meetings was a two-day special course conducted in Knoxville, Tenn., during October by the Commission (see below). Such a program has been called for, not only on the basis of day-to-day operations, but also as a part of the nation's overall mobilization readiness program, since in time of national emergency the number of nuclear shipments conceivably could be doubled or tripled.

During 1961, the Commission stepped up its program of transportation seminars to include bridge, tunnel, and port authorities, ocean carrier and airline officials, and insurance executives. The meetings feature Commission staff presentations and technical discussions related to transportation of radioactive materials, and afford an opportunity for all participants to exchange ideas based on specific handling and transport problems.

On December 28, the Commission announced that it will co-sponsor, with the Interstate Commerce Commission, a series of regional meetings to discuss with State and local officials the safe transportation of radioactive materials. The meetings will be held early in 1962 at Atlanta, New York City, Chicago, and San Francisco in cooperation with the Council of State Governments.

Special Transportation Courses

The first of a series of two-day special courses covering the shipment of radioactive materials was conducted in Knoxville, Tenn., during October by the Commission for representatives of the transportation industry.

The Knoxville radiation protection training course included approximately 42 representatives of 22 airline, motor freight, and railroad firms which carry radioactive materials under the responsibility of the Commission's Oak Ridge Operations. A similar course was held during November in Cincinnati, Ohio.

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Raw Materials Program

Receipts of uranium oxide (U_3O_8), totaled 30,325 tons of U_3O_8 during 1961, of which 17,410 tons were from domestic suppliers, 8,735 from Canada, and 4,180 from overseas.

Projected Procurement

Projected annual purchases for the next five years under existing commitments, including imports, range from approximately 30,000 tons U_3O_8 in fiscal year 1962, to 18,000 tons U_3O_8 in fiscal year 1966.

Annual domestic purchases of uranium concentrates during fiscal years 1962–1966 are expected to range from about 17,500 tons to 16,000 tons U_3O_8 which will provide the domestic uranium industry (privately owned mines and mills) with a substantial continuing market for concentrates derived from ore reserves developed prior to November 24, 1958 (known as "eligible" ore).

Contract Extensions

Nineteen domestic milling contracts extend through 1966, and three contract extensions are in process of negotiation. Three uranium mill contracts will terminate before 1966 because of limited supplies of eligible ore.

More than 90 percent of the ore reserves developed as of November 24, 1958, have been covered by firm agreements fixing production rates and total allocations. Allocations also have been calculated for a large percentage of the small active independently-owned mining properties.

Foreign Procurement

Foreign receipts will decline rapidly after fiscal year 1963 and will total only 2,100 tons by mid-1966.

Canadian purchases in fiscal year 1962 are scheduled to total 7,825 tons U_3O_8, and decline to 500 tons in 1966 at the completion of the program.

The joint United States-United Kingdom Combined Development Agency contract for purchase of South African uranium was replaced by two separate contracts—one between the Commission and the South African Atomic Energy Board, and one between the U.K. Atomic Energy Authority and the Board. Receipts by the United States of uranium concentrates will total approximately 17,000 tons U_3O_8 from July 1961 through December 1966.

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During the past year, the Commission had 250 additional United States patents issued. They are available for licensing to industry on a non-exclusive, royalty-free basis. This made, as of November 30, 1961, a total of 2,734 U.S. patents available for industrial licensing. During the year, the Commission issued an additional 54 licenses on its U.S. patents, making a total of 850 licenses granted.

In addition, 460 foreign patents were released for licensing on a royalty basis. These included 49 in Australia, 118 in Belgium, 79 in Canada, 136 in France, 94 in Great Britain, 43 in Italy, and 21 in West Germany.

On January 24, the Commission published in the *Federal Register* notices concerning its adoption of a policy to charge royalties on certain Commission-owned foreign patents and its adoption of a revised contract policy regarding foreign patents.

Royalties on foreign patents. In the past, the Commission has followed the policy of granting free licenses to all on Commission-owned U.S. patents, and has granted royalty-free licenses to U.S. citizens on Commission-owned foreign patents.

Effective on January 11, the Commission established a policy of granting licenses for royalties on Commission-owned foreign patents to foreign corporations and foreign nationals in those countries where the foreign government charges royalties of the U.S. Government or U.S. citizens. However, the Commission will grant free licenses to foreign corporations and foreign nationals where the foreign government does not charge the U.S. Government or U.S. citizens royalties. Where the foreign government does not have an established policy, the Commission may or may not charge royalties, depending on what is deemed appropriate in a given situation. This policy is designed to establish a more equitable basis from the standpoint of the treatment of patents for the participation of U.S. industry in foreign atomic energy programs.

The royalty license to be granted by the Commission may be nonexclusive or exclusive for a period of three to five years (subject to free license grants to the U.S. Government and to U.S. nationals). The licensee would be authorized, with Commission approval, to maintain suits on the Commission-owned foreign patents under which such party is licensed.

The Commission's policy of granting royalty free licenses to U.S. citizens on Commission-owned foreign patents remains unchanged.

Foreign patent contract policy. The Commission, after studying comments received as a result of a notice published in the *Federal Register*

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of August 12, 1960, approved a foreign patent policy with respect to inventions derived from work performed under Commission contracts in privately owned and operated—as distinguished from government owned and operated—facilities.

Basically, the policy states that in order to obtain foreign patent rights, the contractor must file a United States application which will serve as the basis for a foreign application. The Commission will acquire the rights in the U.S. patent, but the contractor will retain all rights in the foreign patents subject to receipt by the U.S. Government of a non-exclusive, irrevocable license for Governmental purposes, with the right of the U.S. Government to grant licenses to foreign governments for purposes of use by such foreign governments pursuant to a treaty or agreement with the U.S. Government or any agency thereof. The contractor is required to grant, upon request, non-exclusive, royalty-free licenses to United States citizens and must agree to grant foreign users and purchasers of a product of a U.S. licensee, a license at a reasonable non-discriminatory royalty. If, after five years from the issuance of a particular foreign patent, the contractor or its assignee cannot demonstrate, upon the Commission's request, that practical application has been made of the subject matter covered by such foreign patents, the contractor or its assignee shall, at the request of the Commission, grant licenses on any such foreign patents at reasonable royalties.

Information for Industry

Technical Information

The Commission continued to make an increasing amount of technical information available to industry. For instance, with the termination of the Aircraft Nuclear Propulsion program in March, some 30,000 classified documents generated by the activities in this area during the past few years were reviewed. Approximately half of them, many dealing with high temperature work, were declassified.

During the year, 6,200 unclassified reports were provided to the Office of Technical Services, U.S. Department of Commerce, for sale to the public. In addition, the Commission published nine technical volumes dealing with specialized areas of the nuclear energy program and, at year's end, had seven others in the final completion stage. Two others were in the early stages of preparation. Contracts were signed during the year with four scientific societies for the preparation of 15 monographs on scientific and technical subjects. Some 600 translations of foreign publications were made, bringing to more than

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More complete details of this program are included in the Technical Information section of Part 3 of this report.

Access Permit Program

The number of Access Permits in effect continued to show a decline during 1961. The decrease was caused primarily by the Commission's program of continually declassifying technical information generated under Commission sponsored atomic energy work during the past few years. As of November 30, 1961, there were 835 Access Permits in effect, as compared with 1,032 in 1960.

Access to the following additional categories of classified information was provided for civilian uses of atomic energy during 1961: C-24, Isotope Separation-Gas Centrifuge Method; C–90, Nuclear Reactors for Ramjet Propulsion; C–91, Nuclear Reactors for Rocket Propulsion; C–92a, Systems for Nuclear Auxiliary Power (SNAP-Isotopic Program); C–92b, Systems for Nuclear Auxiliary Power (SNAP-Reactor Program); C–93b, Advanced Concepts for Future Application (Reactor Experiments); and C–93b, Advanced Concepts for Future Application (Conversion Devices).

STATE ACTIVITIES

State Assumption of Regulatory Authority

Kentucky was the first State to submit a formal proposal to the Commission for assuming certain regulatory controls over radioactive materials as provided for in a September 1959, amendment to the Atomic Energy Act.[18] The presentation of the State's proposed regulatory program was made during July and a proposed agreement was published in the *Federal Register* on September 29 for public comment. California was the second State to submit a proposed program. Its formal proposal was received by the Commission in December. (See Radiation Standards section in Part 4 for more details.)

Although they have not yet submitted formal proposals, the States of New York, Texas, Mississippi, and New Jersey are also negotiating with the Commission to assume those regulatory functions allowed under the law. Several other States are currently developing plans for consideration by the Commission.

[18] See pp. 266–267, Annual Report to Congress (January–December 1959).

Thirteen States (Arkansas, California, Florida, Idaho, Indiana, Kentucky, Maine, New Jersey, New York, Oregon, Tennessee, Texas, and Washington) have enacted enabling legislation to assume the regulatory authority to be relinquished by the Commission—and one State (Mississippi) determined that no amendment to its statutes was required.

Western New York Nuclear Service Center

The announcement by the State of New York in June of the establishment of a 3,500-acre Nuclear Service Center about 30 miles southeast of Buffalo marked a significant step forward in the development of a viable private nuclear industry. The center will include sites available for lease to private industrial and scientific organizations for atomic industrial and research activities. It has been proposed that the Center include a State owned and controlled facility for the land-burial of radioactive wastes. Such storage operations would be conducted by a Commission licensed industrial concern under contract to the New York State Office of Atomic Development.

The Commission provided advice and assistance to the Office of Atomic Development in the establishment of the Center. Activities, as appropriate, will be subject to Commission regulations.

Southern Interstate Nuclear Compact

The Southern Interstate Nuclear Compact went into effect during June when seven (Kentucky, Louisiana, Tennessee, Arkansas, Texas, South Carolina, and Florida) of the 16 States of the Southern Governors' Conference ratified the pact.

The Compact provides a means for a coordinated effort among the States to achieve optimum benefit for the South from nuclear energy. An autonomous coordinating agency, established under the Compact and known as the Southern Interstate Nuclear Board, will generally oversee the interests of the Southern States in atomic energy. The Board is to keep member States appraised of the position of the South with respect to nuclear and related industries, encourage exploitation of nuclear energy uses, act as a focal point for information and training activities, and generally guide the member States in the formulation of atomic energy development and control programs.

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Part Two

Nuclear Power Programs for 1961

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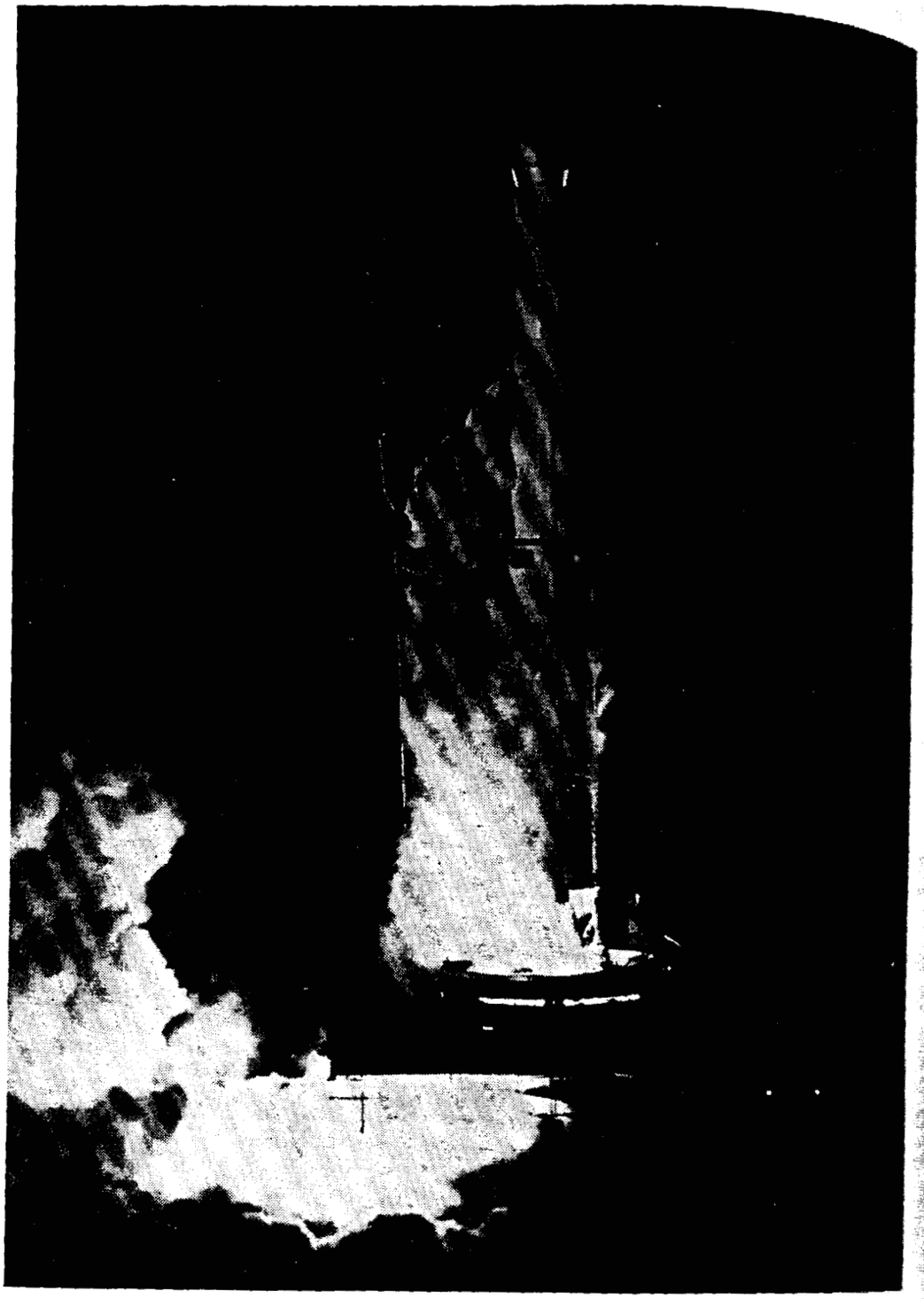

Historic Blast-off. The Navy's TRANSIT 4A satellite is shown leaving Cape Canaveral atop a Thor-Able-Star rocket on June 29 in the first launching of an atomic power source into orbit. Two of the four radio transmitters used in the navigational system satellite are being powered by a five-pound thermoelectric generator fueled with plutonium 238. It generates 2.7 watts of electricity. (Solar cells are providing power for the other two transmitters.) The satellite was covered during the blast-off by the bullet-shaped shroud (top of rocket). On November 15, a TRANSIT 4B satellite carried a second radioisotope-fueled power unit into orbit.

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NUCLEAR POWER FOR SPACE

Development of nuclear energy utilization for aerospace programs is being carried on by the Commission under two programs and in cooperation with other Government agencies. The Systems For Nuclear Auxiliary Power (*SNAP*) program has already proved successful with the orbiting, during 1961, of two TRANSIT navigational satellites each carrying radioisotope-fueled "batteries" which provide power for the satellites' radio transmitters. The second program is that involving nuclear-propelled rockets, Project *ROVER*, which is carried on in cooperation with the National Aeronautics and Space Administration. (Work in the nuclear ramjet feasibility program, Project *PLUTO*, is reported under Military Reactors.)

Systems for Nuclear Auxiliary Power (SNAP)

The objective of the SNAP program is to develop small, lightweight nuclear power sources for satellites, space craft, and for other special applications with appropriate safety review by the Commission. *Odd*-numbered SNAP projects use the heat from the decay of selected radioisotopes, with the units being developed for the Commission by The Martin Co. (now Martin-Marietta Corp.). *Even*-numbered SNAP projects use heat from the operation of compact reactors which are under development by the Commission's contractor, Atomics International.

Rotating and static power conversion systems utilize the heat provided by the SNAP units. With the exception of SNAP–10A, all reactor units under development are planned for use with rotating or turboelectric power conversion systems. Advanced systems may employ thermionic conversion. The SNAP radioisotope units presently being developed are for use with static power conversion systems, either thermoelectric or thermionic.

SNAP Radioisotope Projects

A major milestone in the SNAP program was reached June 29, when a small plutonium 238-fueled thermoelectric generator, similar to a SNAP–3 type,[1] was successfully placed in orbit as a power source in the TRANSIT–4A navigational satellite. A second such SNAP unit was used in the TRANSIT–4B satellite put into orbit on No-

[1] First demonstrated at the White House on January 16, 1959.

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vember 15, 1961. The five pound, 2.7-watt generators are powering two of the four navigational transmitters in each of the orbiting satellites and are expected to continue satisfactory operation for several years. These small generators are the first steps in the program now underway to develop a radioisotope thermoelectric generator (designated SNAP–9A) for the full-scale operational TRANSIT navigational system. The purpose of the TRANSIT satellites is to provide a worldwide means for ships and aircraft to determine accurately their positions electronically rather than through celestial observations.

Forerunner Device. Performance of the Commission's first two SNAP (Systems for Nuclear Auxiliary Power) devices to be placed in orbit are being evaluated for future use of higher-powered nuclear generators in the nation's space effort. Photo shows the first SNAP generator to be placed in orbit being attached to the Navy's TRANSIT 4A satellite. The tiny spherical atomic device (center of photo) is instrumented so that its performance in space can be monitored by tracking stations throughout the world. Two such satellites were placed in orbit on June 29 and November 15, 1961. The plutonium 238 thermoelectric generators were developed for the Commission by the Martin-Marietta Corp.; the navigational satellites were developed for the Navy by the Johns Hopkins Applied Physics Laboratory.

The SNAP–1A, a project initiated to develop a thermoelectric generator to produce 125 watts of electricity for one year in space, was

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re-evaluated and terminated early in 1961. After cancellation of the Air Force requirement for such a generator in October 1959, plans were revised to provide for environmental tests of an electrically heated, non-fueled unit, and hot-cell tests of a cerium 144-fueled unit. The environmental tests were conducted but the planned tests of the fueled unit were cancelled and the effort was terminated in an orderly manner. Fabrication and testing of the thermoelectric modules were completed in June 1961 and the technology developed is now being applied in the other SNAP programs.

The SNAP–7 power units are strontium 90-fueled thermoelectric generators being developed for remote, unmanned terrestrial applications. SNAP–7A and SNAP–7C are 5-watt systems, and SNAP–7B and SNAP–7D are 30-watt units. SNAP–7C was delivered to the Navy in October, and was then shipped to the Antarctic where it will power an automatic weather station. SNAP–7A was delivered to the Coast Guard in December for test in a navigation buoy. The larger 30-watt units will be delivered in 1962. SNAP–7B will be used by the Coast Guard in a land-based navigation light, and SNAP–7D will be used by the Navy in an unmanned floating weather station.

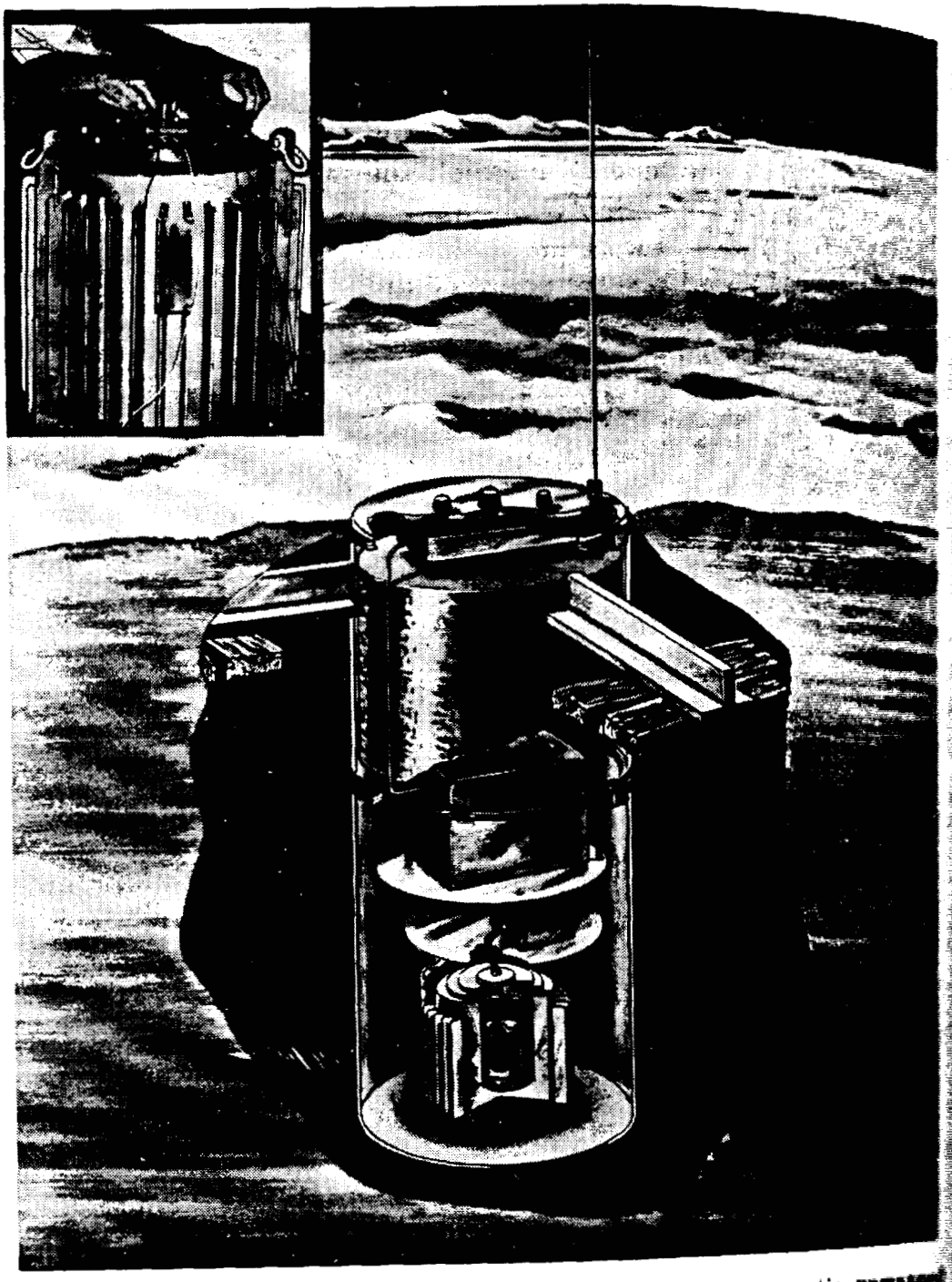
The Commission is developing SNAP–9A for use in the Navy's operational prototype TRANSIT satellites beginning in 1962. SNAP–9A is a plutonium 238-fueled thermoelectric generator with a design lifetime of 5–10 years. The generator will weigh approximately 27 pounds and will be 20 inches in diameter and 10 inches high.

The SNAP–11 project relates to the use of a SNAP unit for the SURVEYOR "soft" lunar landing missions planned by the National Aeronautics and Space Administration (NASA). Atlas-Centaur trajectories from Cape Canaveral, Fla., are being analyzed (with regard to where the space unit would fall in case of an abortive launch) and anticipated lunar impact conditions are being studied to determine the feasibility of a SNAP generator for the soft lunar landing. Preliminary results, presented to NASA in March 1961, indicate the feasibility of using a curium 242-fueled 25-watt thermoelectric generator on SURVEYOR space craft. This evaluation indicated that such a power source would increase substantially the scientific value of the SURVEYOR missions. The process for producing gram quantities of curium 242 is being developed and the first samples are now being irradiated in the Commission's Materials Testing Reactor in Idaho. A prototype development program for SNAP–11 is being formulated.

In September, the program to develop a low-powered, curium 242-fueled, thermionic generator to demonstrate the feasibility of the close-spaced vacuum diode as a space power supply was terminated. The results indicated that a generator efficiency of 2.5 percent was the maximum to be expected from this type system. The vacuum

diode approach was abandoned in favor of the very promising cesium diode. It is planned to fuel a thermionic cesium diode generator, designated SNAP–13, in late 1962.

A flight test program was conducted in which Atlas E pods were used to test experimentally the validity of the theoretical heating



Antarctic Weather Station. Artist's drawing of the Navy's automatic, unmanned weather station now being emplaced in the Antarctic and which will be powered by a SNAP–7C power unit (shown at base of drawing and in the photo insert). The strontium 90 generator is approximately 21 inches tall and 19 inches in diameter. It will provide five watts of electricity continuously for at least two years to power the weather telemetering station. The nuclear thermoelectric generator was built for the Commission by the Martin-Marietta Corp.

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rate and heat transfer rate equations for use in the analysis of atmospheric burnup of SNAP isotope devices during re-entry. The first test was successfully completed in July. Additional tests were conducted during November and December.

A feasibility study on the use of calcined mixed fission product wastes as heat sources for electric power was completed by the General Instrument Corp. in early 1961. The favorable results of the study have justified initiating the second phase—the development, for electrical heat testing, of a 5-watt device designed to use waste products from the Idaho Chemical Processing Plant.

SNAP Reactor Projects

The goal of the *SNAP–2* effort is to develop a very compact 3 ekw (electrical kilowatt) reactor-turboelectric system for space applications. Development work began in 1956 and is continuing. Delivery of systems for flight development tests should take place in 1964. The effort on SNAP–2 also provides basic research and development work on compact reactor technology and miniaturized conversion equipment.

A prototype SNAP–2 reactor, designated the SNAP Experimental Reactor (SER), successfully completed initial testing on November 4, 1960. A second developmental reactor is to be combined with a turboelectric power conversion system and tested as the SNAP–2 Development System (S2DS) early in 1962. The reactor for the S2DS went critical in April at the Commission's facility operated by Atomics International at Santa Susana, Calif. After low-power tests, the reactor began power operation in August.

The *SNAP–4* project originated during 1959 as a feasibility study on the development of a very compact reactor-turboelectric system with the capability of long unattended life in an underwater or remote terrestrial location. Design study and component development were started in 1960 for this experimental reactor. The reactor is to use SNAP–2 hydride fuel technology and boiling water as a coolant in a single-loop system. The SNAP–4 project would require the development of compact turboelectric generators capable of generating 1,000 to 4,000 ekw. Design and development work on system components continued through the year.

The *SNAP–8* project is a joint Commission-NASA effort to develop a nuclear electric generating system for the NASA space program to be used for power in orbital test of experimental electrical propulsion devices. The reactor is to have the thermal capability to run one or two 30 ekw turboelectric units. The Commission is responsible for the development of the reactor, reactor control, and shielding, and

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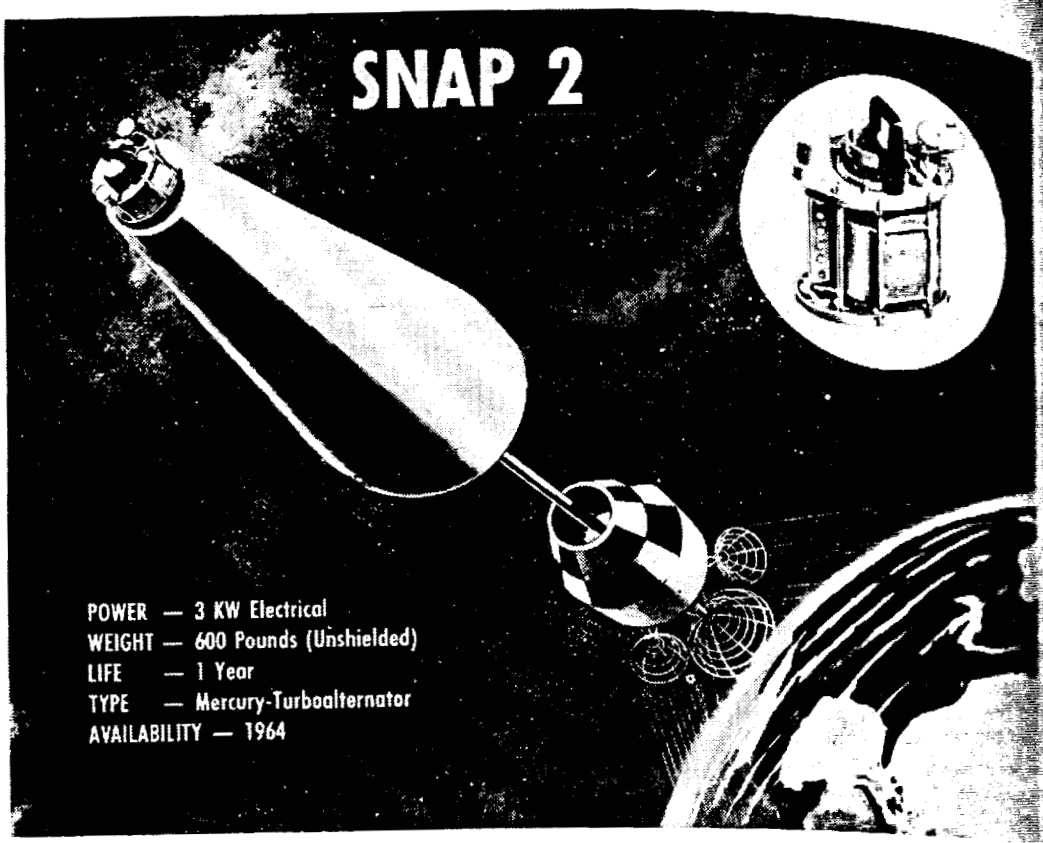
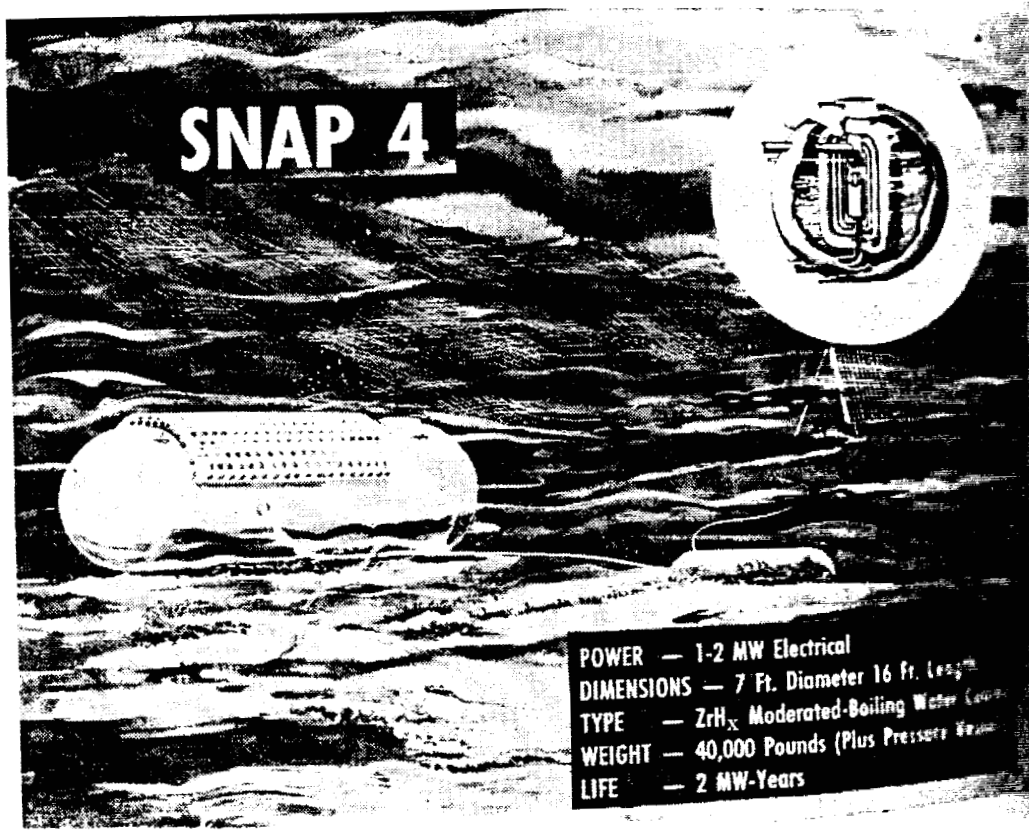


Space and Undersea SNAP Units. Even-numbered SNAP units utilize very compact nuclear reactors to generate power. *Drawing above* shows the SNAP-2 concept which is being developed for space applications requiring three kilowatts of electricity. *Drawing below* is the SNAP-4 device which could be used for underwater devices requiring 1,000 to 4,000 kilowatts of electricity. Both devices are being developed for the Commission by Atomics International. The inset in both drawings shows the SNAP device.



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NASA is responsible for the development of the power conversion equipment and integration of the reactor and conversion equipment into an operational system. NASA is also responsible for its subsequent integration into a suitable flight vehicle and for the flight test of the entire system. The reactor core design has been completed and calls for 600 thermal kilowatts and a sodium-potassium coolant exit temperature of 1,300° F. Fabrication of the first SNAP–8 experimental reactor began in March and will be completed in April 1962. Design of the SNAP–8 ground prototype nuclear test facility has been approved and construction at Santa Susana began in December. This facility is scheduled for completion by the end of 1962.

The *SNAP–10A* project is designed to produce a low-power, lightweight, electric power source for space operation and military purposes. A SNAP–2 type reactor is to be used at 30 thermal kilowatts output with sodium-potassium liquid metal coolant. The coolant is to be pumped by an electromagnetic pump from the reactor core to the thermoelectric elements where the heat is converted directly into electricity. After orbital startup, the system will not require active control and will have no moving parts. The system will produce 500 watts of electricity at a design weight, including shielding, of 750 pounds. Design of the flight systems was initiated in July, and the first nonnuclear mass mockup system was completed in November.

Orbital flight tests of SNAP–2 and SNAP–10A devices are anticipated in the 1963–65 time period as a joint AEC-Air Force effort designated SNAPSHOT, which is designed to demonstrate the feasibility of use of small compact reactors in space. The reactor power systems will be launched in an inert condition and will be started up after a long-lived orbit is established.

Space Propulsion Reactors

The Project *ROVER* nuclear rocket program, conducted by the Commission jointly with the National Aeronautics and Space Administration (NASA), has as its ultimate aim the development of nuclear rocket propulsion systems for manned or unmanned space exploration. Such nuclear systems have significant advantages over chemical rockets, particularly for the longer space missions, because of their higher specific impulse (thrust per pound per second of propellant

The *ROVER* program was started by the Commission at the Los Alamos Scientific Laboratory in 1955. After an initial period of development work, a basic complex of test facilities was constructed at the Nevada Test Site for the assembly, test, disassembly, and post-mortem examination of experimental reactors. KIWI–A, the first of

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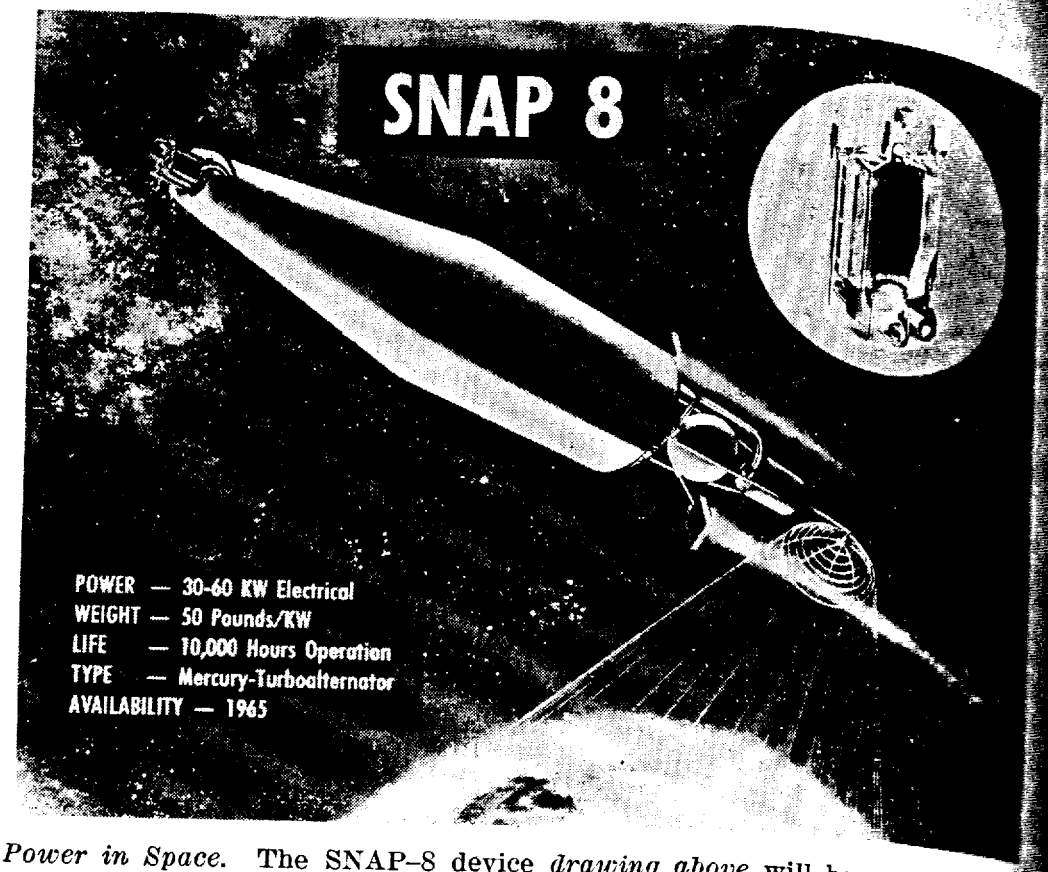
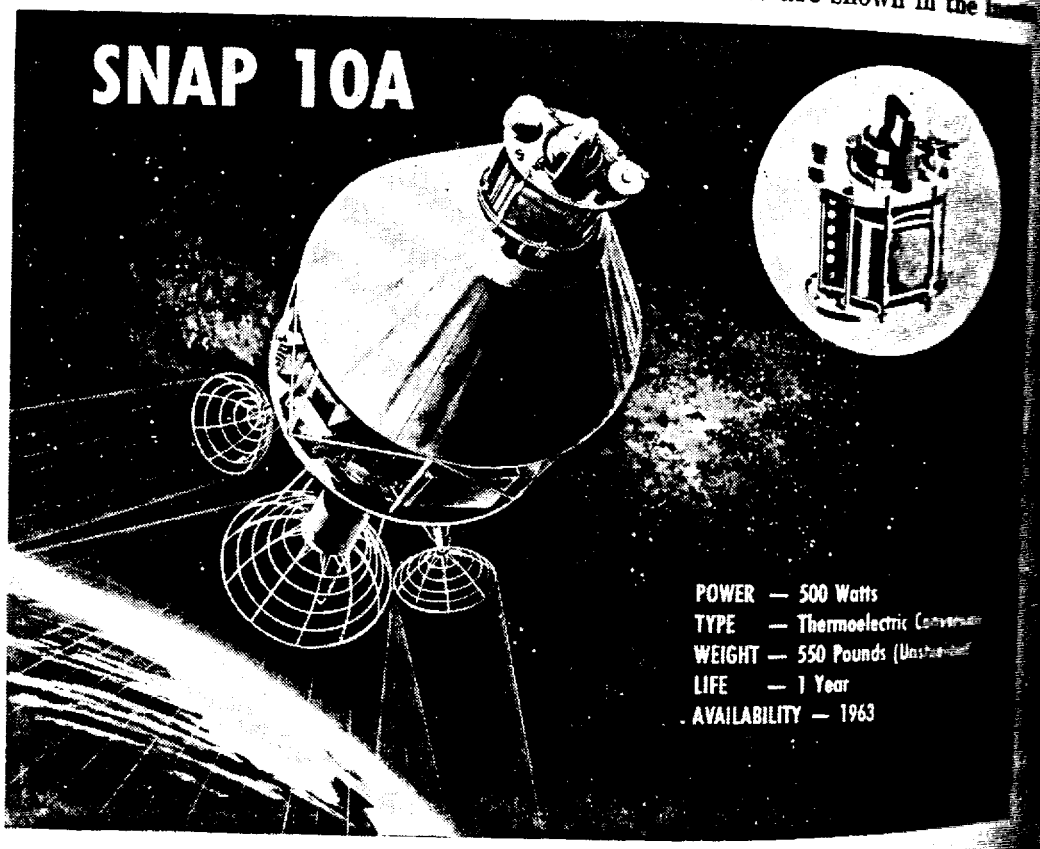


Power in Space. The SNAP–8 device *drawing above* will be a reactor turbo-electric conversion system producing 30 or 60 electrical kilowatts for the joint Commission-NASA space program. *Drawing below* shows the SNAP–10A unit which will produce 500 watts of electricity for the Commission-Air Force space program. Both of the SNAP devices are being developed by Atomics International under Commission contract. The SNAP units are shown in the large



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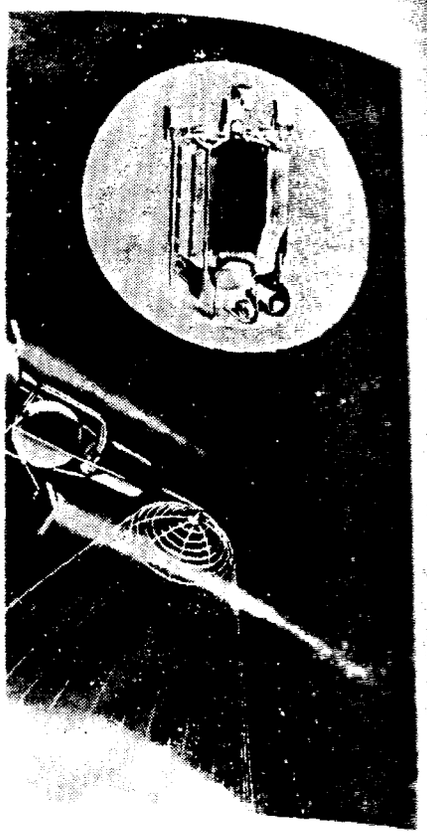

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series of non-flyable experimental reactors, was tested in July, 1959. KIWI-A Prime and KIWI-A3, improved versions of KIWI-A, were tested in July and October 1960, respectively. The success of these tests permits reasonable expectation of rapid technical progress toward flight-performance reactors.

The primary objective of the nuclear rocket propulsion effort is to demonstrate nuclear rocket flight as early as is technically feasible and consistent with assurance of safety and good probability of successful flight. A major step in the development of *NERVA* (Nuclear Engine for Rocket Vehicle Application) to operational use will be the initial in-flight test series which may reasonably be anticipated in the 1966–67 period. It is presently planned to test a NERVA engine in an upper-stage of a Saturn-class launch vehicle. The flight-test vehicle would be lifted off the ground by the chemical booster, with the nuclear engine starting during flight as the chemical booster finished firing. The path of the vehicle will be ballistic, with the trajectory controlled so that the vehicle travels almost completely over water to its target impact point in the ocean.

The major technical effort during 1961 was devoted to additions and modifications to the KIWI ground test facilities at the Nevada Test Site (NTS) for the more complex higher-power tests needed as the next step in the development of flyable reactors; to the design changes to the reactor and technical development suggested by the results of the first three tests; and the KIWI-B1-A reactor test on gaseous hydrogen which took place on December 7.

The first liquid hydrogen test, which will initiate an accelerated series of tests, will take place early in 1962. The facilities work during 1961 included modification of one test cell for liquid hydrogen operation, partial construction of a second test cell, the initiation of construction on the first engine test stand, expansion of the present Maintenance, Assembly, Disassembly (MAD) building, and the design and engineering of a MAD building for the engine development tests.

In July, the Joint Commission-NASA Space Nuclear Propulsion Office, which manages the nuclear rocket program, contracted with Aerojet-General Corp. for initial work in the development of the first nuclear rocket engine using the reactor technology developed in the KIWI effort. Westinghouse Electric Corp. is the major sub-contractor to Aerojet-General in this work. The present work of Aerojet-General and Westinghouse includes preliminary design of the NERVA engine, assistance to the Los Alamos Scientific Laboratory in certain tasks, assistance in the design of facilities, preparation of a detailed plan for development of NERVA, and a number of research and development tasks.

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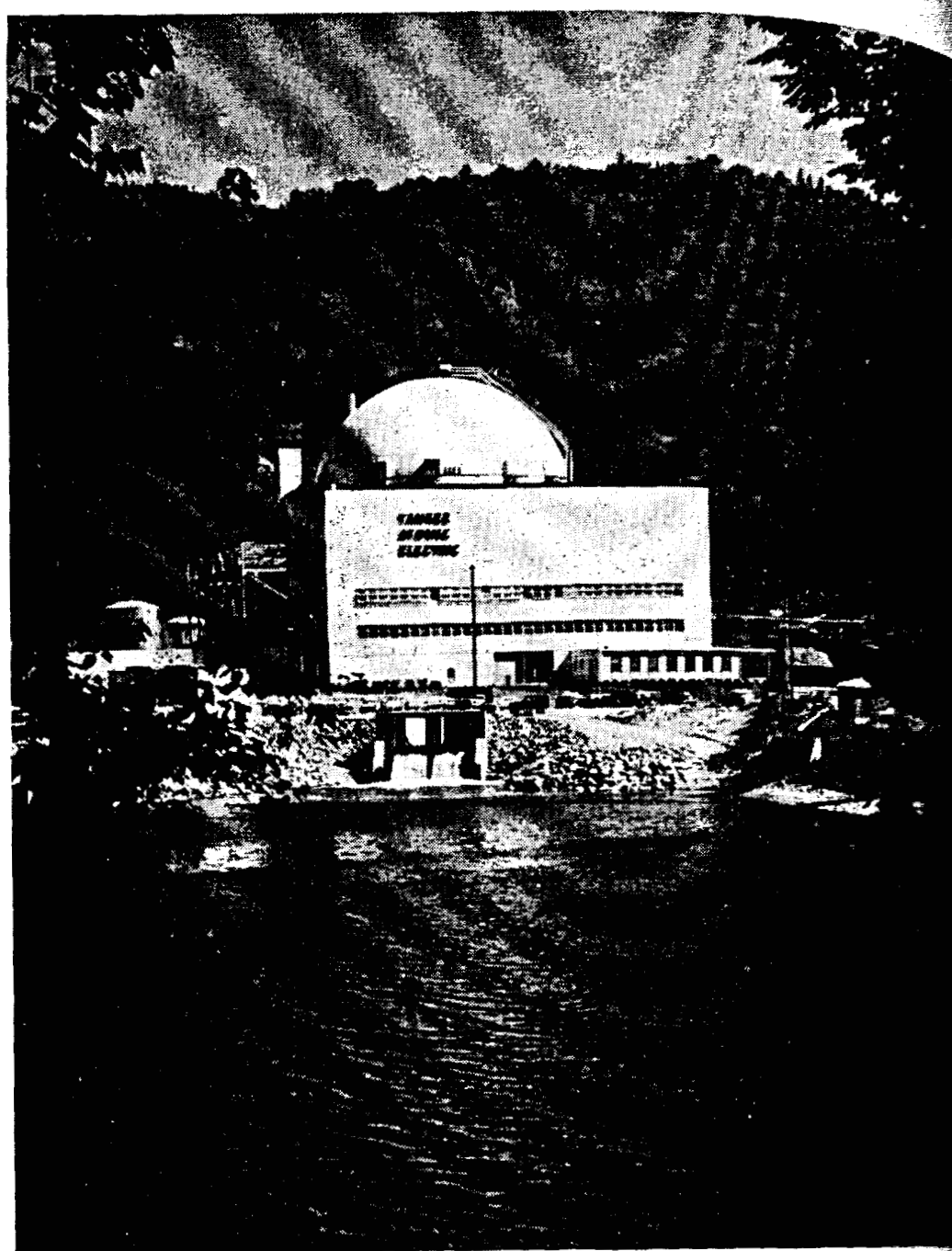

First PDRP Plant. First electricity generating plant to be built under the Commission's Power Demonstration Reactor Program (PDRP), the Yankee Atomic Electric Co. facility at Rowe, Mass., surpassed design expectations during its first year of operation. Constructed as a 110,000 electrical kilowatt generating station, the Westinghouse Electric Corp.-built pressurized water reactor is producing enough heat to generate 141,000 ekw. Company officials are also predicting the production of power at a lower mills per kilowatt hour cost than was anticipated. The plant is located on the Deerfield River (foreground) in northwestern Massachusetts.

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PROGRESS IN POWER REACTOR TECHNOLOGY

Reactor projects under the civilian nuclear power program are financed in three ways: by the Government, as Commission experiments; by private industry, as prototype or commercial-scale plants; and by the joint effort of the Government and utility organizations. Of the projects described in this section, 25 will produce, or are producing, usable amounts of electricity. Six of these projects are experimental reactors financed by the Government; seven are privately owned projects; and 12 are projects financed jointly by the Government and utility organizations as a part of the Commission's Power Demonstration Reactor Program.

Power Demonstration Reactor Program

As a means of stimulating industrial participation in the development and application of nuclear technology to the generation of power for civilian use, the Commission instituted a cooperative effort known as the Power Demonstration Reactor Program (PDRP) in January 1955. In the first years of this program, the Commission issued three invitations for private participation, each invitation covering a somewhat different form of cooperative financing arrangement.

The first invitation was a general one and did not specify reactor type or size. Under this "first round" invitation, three projects (Yankee, Fermi, and Hallam) were initiated.

In September 1955, a second invitation for small plants only was extended, and in January 1957, a third invitation essentially similar to the first, was extended. These "second-round" and "third-round" invitations represent the two basic types of Commission-utility cooperative arrangements which have been used in the Power Demonstration Reactor Program.

Under the second-round type of arrangement, the Commission builds and owns the nuclear steam supply system, conducts all nuclear research and development required, and defrays all costs of operating the nuclear portion of the plant. The participating utility which, under existing law must be a cooperative or publicly owned organization, provides the site and the conventional non-nuclear facilities associated with a power plant, operates the plant, purchases from the Commission the steam produced by the reactor, and has the option to own the reactor. In the present program, three reactors (Elk River, Piqua and BONUS) are under construction and one (LaCrosse) has been proposed on the basis of this type of arrangement.

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Under third-round contractual arrangements, the participating utility, which may be a public or private organization, is responsible for all capital costs associated with the plant and thus constructs, operates, and owns the entire facility (except for the nuclear fuel), while the Commission pays for at least part of the nuclear research and development work associated with the project and waives the fuel use charges for a specified time. Three projects (Pathfinder, Big Rock Point, and Carolinas Virginia) are being built under this arrangement and two others (Peach Bottom and Southern California Edison) have been proposed.

Pressurized Water Reactors

Shippingport Atomic Power Station

The Shippingport Atomic Power Station, which utilizes a pressurized water reactor, completed four years of successful operation in December as the first large-scale nuclear power electrical generating plant in the United States. This plant achieved criticality and began full power operation in December 1957, and presently supplies 60,000 kilowatts net of electricity. Since initial operation, the reactor has operated for 15,279 equivalent full power hours and more than a billion kilowatt hours of electricity have been generated. This is sufficient electricity to supply the residential needs for more than 80,000 families during the four years that the Station has been operating.

The electricity generated is used in the Pittsburgh, Pa., area on the distribution system of the Duquesne Light Co., which operates the Station for the Commission.

During the entire period of supplying power to the Duquesne system, the reactor plant has demonstrated flexibility and load change characteristics superior to those found in conventional steam generating equipment. In addition to providing valuable data on the performance of a nuclear reactor plant as an integral part of a large electric utility system, the Shippingport plant has demonstrated the high degree of reliability that can be obtained with this type of reactor. For example, during the 15 months of Shippingport operation with Seed 2 installed in the reactor core, the reactor was used more than 97 percent of the time for power generation, testing, and training; it was shut down less than three percent of the time for maintenance.

The primary objective of the operation of the Shippingport Station is the advancement of reactor technology and developing information useful in the design and operation of nuclear power plants. To this end, the reactor plant and core are heavily instrumented and in the four years since startup, numerous tests have been conducted to

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evaluate the design and the performance of the reactor, its fuel elements, and the reactor plant as a whole. The information from these tests has provided much of the technology, operation and cost data available on large water-cooled reactors for commercial generation of electrical power.

In addition to the above, contributions during the past year resulting from the operation and testing of the Shippingport plant include:

Continued successful operation of the zircaloy-clad natural UO_2 fuel elements in the reactor. These fuel elements have reached a higher fuel burnup than that achieved in any other reactor.

Further confirmation of the advantages of the "seed and blanket" core concept in which substantial amounts of power are obtained from natural uranium with a small investment in uranium 235.

Acquisition of data on the long-term behavior of major plant components, and thus obtaining a realistic basis for judging the adequacy of component design specifications.

Demonstration of how a large, heavily instrumented power reactor can be refueled. This second refueling was performed in a relatively short period of time by preparation of detailed procedures and by training the refueling personnel.

Publication and distribution of the results and evaluations of approximately 130 tests covering both the nuclear and thermal performance of the reactor plant and its associated systems. This brings the total number of technical reports issued for distribution by the Shippingport project to more than 1,500.

During the first half of 1961, the reactor was operated most of the time at full power to develop information on the lifetime capabilities of the natural uranium oxide fuel elements. In addition, numerous reactor and plant tests were conducted and reactor operators from both the United States and foreign countries were trained at the Commission's Nuclear Power Training School at the Shippingport Atomic Power Station.

Following the performance of the numerous end-of-life physics tests in June and July, depletion of Seed 2 was achieved on August 11, and after completion of remaining plant tests refueling of Seed 2 with Seed 3 was started on August 16. Seed 2 had operated for a total of 7,200 equivalent full-power hours. This compares with 5,806 equivalent full-power hours of operation on Seed 1. Refueling was completed on October 6, and the reactor, containing the new seed, went critical the next day. It was operated at full power through the end of the year. As of December 31, 1961, the total hours of operation, the burnup and electricity produced at Shippingport since initial startup in December 1957 were as follows:

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Equivalent full power hours of operation on Core 1: 15,279;
Average fuel burnup in blanket, megawatt-days per ton of UO_2: 5,000;
Peak fuel burnup in blanket, megawatt-days per-ton of UO_2: 22,000; and
Total electricity generated in gross kilowatt-hours: 1,008,550,300.

The blanket fuel elements were designed for a lifetime objective of 8,000 equivalent full power hours. This objective was actually achieved on September 9, 1960. When Seed 3 is depleted, the blanket fuel elements will have operated for approximately 20,000 equivalent full power hours. Preliminary evaluation of some of the blanket fuel elements removed during the second seed refueling for detailed examination shows them to be in very good condition and the blanket may therefore be satisfactory for operation through a fourth seed lifetime.

The design and fabrication of a second Shippingport core of advanced design is underway. This new core, PWR Core 2, will have a power capability of 150,000 gross electrical kilowatts, and will have a design lifetime of 20,000 equivalent full power hours. This results in a design energy output 5½ times that of PWR Core 1. In addition, PWR Core 2 will have a new mechanical and refueling arrangement; will utilize a new and advanced type of fuel element consisting of oxide fuel plates clad with an improved zirconium alloy in both the seed and blanket; will be heavily instrumented; and will use 20 instead of the 32 hafnium control rods and control drive mechanisms used in PWR Core 1. To dissipate the higher power which will be generated by PWR Core 2, a 50,000 kilowatt heat sink is being installed at Shippingport. The heat sink, along with the existing 100,000 kilowatt turbine-generator, will meet all the requirements for proving out the higher power capability of PWR Core 2.

Yankee Nuclear Power Station

The Yankee Atomic Electric Company's pressurized water reactor at Rowe, Mass., was the first project to be undertaken and the first to be completed under the Commission's Power Demonstration Reactor Program. Criticality was achieved in the Yankee reactor in August 1960, and, following startup and low power testing, operation was begun at the first core design power level of 392 thermal megawatts (corresponding roughly to a net electrical output of 110,000 ekw) on January 17, 1961.

A 500 hour test at full power was completed on February 8 which confirmed the previously held belief that the Yankee first core thermal capability exceeded the design value. The results from this test provided information which formed the basis for the Yankee requ

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the Commission to increase the licensed maximum thermal power el from 392 megawatts thermal (Mwt) to 485 Mwt and to extend e term of the operating license to November 1997. Following review the Commission's regulatory staff and the Advisory Committee on actor Safeguards, and a public hearing, the requested changes in e license were approved by the Commission and became effective in ly. The operating power level was thereupon successfully raised 485 Mwt (corresponding roughly to a net electrical output of 141,000 kw). The reactor was placed in commercial operation in July 1961, d has operated at various power levels up to full power since then. The reactor has operated reliably and well—its behavior being in ordance with earlier predictions. The plant has demonstrated bility under all operating and transient conditions and the reactor s been available for the generation of power in excess of 90 percent the time during 1961. The maximum plant use factor achieved to te (98 percent) occurred during the month of March. The cumula- e electrical output of the plant as of December 31, 1961, was 347,300 kilowatt hours. Core I is scheduled for discharge in bruary 1962. Core II will be identical to Core I.

On June 29, the President of Yankee Atomic Electric Co. an- nced that the total project costs were lower than anticipated— oximately $43.7 million as compared to the $57 million estimated the time the financial arrangements were established in 1957. The t of power from the Yankee first core is estimated to be in the range 11 to 13 mills as opposed to previous estimates of 12 to 14 mills per watt hour. It is anticipated that costs may be further reduced by s of more advanced design.

all Pressurized Water Reactor

The Commission's proposed project for construction of a small (22,- ekw) prototype pressurized water reactor plant, with a conven- al-fueled superheater, was deferred in March 1961 when site and factors proved incompatible with the project plans. The invita- for its construction under the Power Demonstration Reactor Pro- had been issued in August 1959.

The Commission determined that the proposals submitted by the of Jamestown, N.Y., and the Dairyland Power Cooperative, rosse, Wis., for participation in the small power reactor project r a second round arrangement were unacceptable. Of the five onses to the invitation, these two had been found the most accept- although in both cases the Commission requested alternate site osals for public safety reasons. However, the proposed alternate while acceptable from the standpoint of safety, introduced ad-

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verse changes in the initial proposals, and greatly increased the estimated cost of the project to the Government. The cost increase stemmed primarily from the need for the utilities to procure sites sufficiently remote from a population center to meet current site safety criteria for a nuclear power plant in the 20,000-electrical-kilowatt range. The increased capital and operating costs would have resulted in both cases from extended utility lines, additional transmission lines and substations, and substantially increased site development costs.

Despite the uncertain economic outlook, unsolicited proposals from the Wolverine Electric Cooperative of Michigan and American Radiator and Standard Sanitary Corp. were submitted in April in furtherance of a small pressurized water reactor project to be located on Wolverine's electrical system. However, the Commission did not accept the proposals and has deferred indefinitely consideration of alternate plans for a small nuclear plant. A Commission review made in connection with the President's request in October that all Government agencies postpone deferrable projects, showed that this project could be deferred with the least detrimental effect on the reactor program.

Low Temperature Process Heat Reactor

In May, the Commission invited expressions of interest from industrial organizations who use process steam, regarding their possible participation in a demonstration low-temperature process steam reactor project. A demonstration plant was expected to provide technical and economic data on the practicality of nuclear process heat plants for use in industrial operations requiring large amounts of heat such as chemical processing, paper and pulp production, and the conversion of saline water to fresh water.

Formal expressions of interest were received from eight firms. During review of these expressions of interest it was determined by the Commission not to go forward with this project. This project, like the Small Pressurized Water Reactor project mentioned above, was placed in a deferrable status because of its low priority in the over-all reactor program. However, the Commission expects to continue, in its over-all reactor program, selected research and development applicable to these two reactor types.

Southern California Edison Reactor

The Southern California Edison Co. and the Westinghouse Electric Corp. formally proposed, during April, to participate with the Commission in a full-scale, pressurized water reactor of 355,000 net ele

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pacity as an unsolicited project of the third round type. (The companies had previously announced their intention of submitting h a proposal during April 1960.) The proposal by Southern Cali-nia Edison covers operation of the nuclear power plant, while plant velopment, design, and construction would be carried out by West-house and its subcontractor, the Bechtel Corp. Nuclear fuel serv-for the plant would be supplied by Westinghouse. Financial as-ance by the Commission would total about $17 million, including search and development assistance and waiver of fuel use charges.

Under the proposal, the estimated capital cost of the plant to South-California Edison would be $78 million, and commercial operation uld begin by early 1965. However, the Edison proposal is con-ent, among other things, upon the company's obtaining a satis-tory long-term lease of a site on the Marine Corps reservation at mp Pendleton in Southern California. At year's end, the site ques-n still had not been resolved.

solidated Edison Thorium Reactor

Construction of the privately financed uranium oxide-thorium oxide solidated Edison Co. reactor was essentially completed at Indian nt, N.Y., in December. Initial criticality is expected by early 2. Full power operation of the 255,000 ekw pressurized water nt, which includes 104,000 kilowatts from an oil-fired superheater, heduled for the spring of 1962. The Indian Point plant will pro-important operating data for large water-cooled reactor systems technical data on the use of a fuel mixture of thorium and urani-235. It will be the second large-scale nuclear power plant to be into operation without financial assistance from the Commission; sden was the first. A public hearing to consider the issuance of a visional operating license was held on December 7–20, 1961, and ssed to January 3, 1962.

xon Nuclear Experimental Reactor

nstruction work was essentially completed in December on the ately financed 3,250 ekw developmental reactor of the Saxton Nu-Experimental Corp. at Saxton, Pa. The small pressurized plant was designed and built by the Westinghouse Electric It will be operated primarily for research and development ill be connected to an existing turbine generator for production ctrical power at the Saxton steam generating station of Pennsyl-Electric Co., about 20 miles southeast of Altoona. Design operation is expected to be achieved in March 1962. A provi-operating license was issued November 15, 1961.

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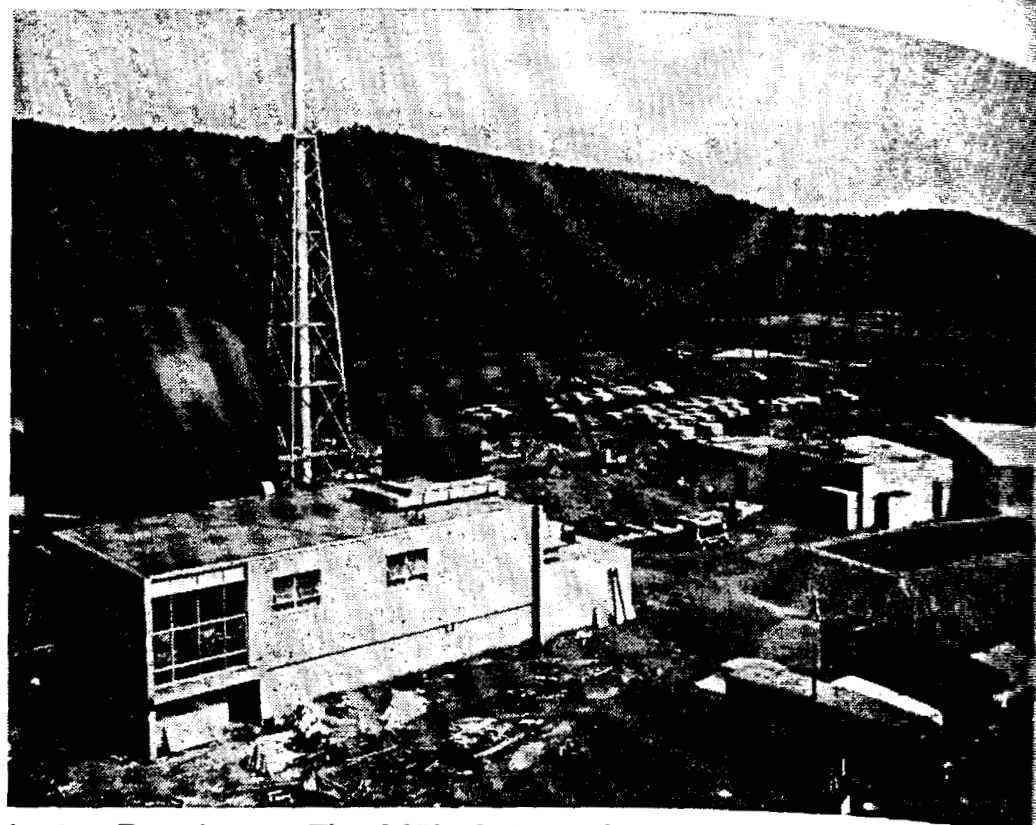

Saxton Experiment. The 3,250 electrical kilowatt pressurized water Saxton Nuclear Experimental reactor plant at Saxton, Pa., is expected to begin power production in March 1962. The privately financed facility, 20 miles south of Altoona, was built by the Westinghouse Electric Corp. The reactor will be operated primarily for research and development, but is connected to an existing turbine generator for production of electricity at the Saxton steam generating station of the Pennsylvania Electric Co.

Boiling Water Reactors

Experimental Boiling Water Reactor (EBWR)

Operation of the Commission's *EBWR* was resumed at the Argonne National Laboratory during April, but only at a limited power rating of 20 megawatts, thermal (Mwt). The modification providing for additional heat removal capacity was essentially completed at the end of 1961. Full power operation at 100 Mwt is expected early in 1962. The electrical capacity of the plant remains at 4,500 kilowatts.

Considerable difficulty was experienced in repairing two major pieces of heat removal equipment, the primary reboilers, which had proven to be defective. The reboilers were twice rejected for failure to pass leak tests. Corrective measures were also taken with the 17-4 PH stainless steel components in the control rod drives of the EBWR. All of the drives were removed and examined. Additional pieces of the 17-4 PH stainless steel components, heat treated to 1,100° F. instead of the previous figure of 900° F., were ordered and installed.

The EBWR, which began operation in 1956 as one of the first developmental boiling water projects, will be used in the first part

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for verification of maximum stable power operation, investigation of steam separation phenomena, determination of hydrodynamic characteristics, and evaluation of carbon steel material.

Plans are being made to close out the research and development program on boiling water reactors at Argonne National Laboratory by the end of fiscal year 1962. This includes an orderly close-out of EBWR, for which no operating funds for fiscal year 1963 have been planned. However, consideration is being given to use of the EBWR for other purposes.

Elk River Reactor

Fuel fabrication difficulties and investigation of cladding cracks in the pressure vessel have further delayed initial criticality of the 22,000 ekw boiling water reactor being built at Elk River, Minn., by the Rural Cooperative Power Association and the Commission under second round arrangement.

About 40 fuel pins exhibited leakage which was traced to microscopic cracks in the end-cap welds. Further environmental tests confirmed the leakage as resulting from low boron content in the end caps of the fuel pins. New high boron content end caps were used in the repair of the leaking pins.

The cladding cracks were discovered in the stainless steel weld overlay of the reactor vessel and also in the cladding within the vessel head. The reactor vessel head was returned to Pacific Coast Engineering Co. for replacement of the stainless steel overlay. Proof testing of cladding integrity in all areas of weld overlay must be completed to verify vessel adequacy. Repair of the vessel and evaluating the results of the integrity tests have delayed the startup date indefinitely.

Since problems with the 17–4 PH stainless steel used in control mechanisms of other reactors were found, all control rod drive units in the reactor were removed for additional heat treatment, which is expected to alleviate the problem. The drive units have since been reinstalled.

Big Rock Point Plant

The Commission announced in January that it had signed definitive contracts with Consumers Power Co. of Michigan, and with the General Electric Co. regarding the 48,000 ekw high power density, direct cycle, boiling water reactor being constructed at Big Rock Point, Mich. The plant is being built under a third round type cooperative arrangement.

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Under the contract between the Commission and Consumers, the company will design, construct, and operate the nuclear power plant at its own expense. The Commission will reimburse the company for costs up to $500,000 in connection with the research and development program, and will waive fuel use charges valued at about $1,650,000 for the first five years of plant operation.

Under the contract between the Commission and General Electric, the Commission will support research and development up to a maximum cost of about $3,700,000 subject to an upward escalation with a ceiling of 10 percent. The objectives of the development program, including a 4½-year test and evaluation effort in the Consumers plant are: (*1*) To demonstrate the feasibility of increasing the power density of oxide-fueled, boiling water reactors; (*2*) to determine the effects of high power density operation upon fuel life exposure; (*3*) to reduce the fabrication cost of high performance fuel; and (*4*) to determine the optimum conditions for high power density operation in the Consumers' plants.

Consumers estimates the capital costs for the plant, including site and site preparation, to be about $27,700,000. Construction was about 80 percent complete at the end of 1961, and the reactor is scheduled to go critical in September 1962.

Prototype Boiling Water Reactor

In February, the Cities of Los Angeles and Pasadena, Calif., jointly notified the Commission that they were withdrawing their proposal for participation in a 50,000 ekw Improved Cycle Boiling Water Reactor (*ICBWR*) project. Their decision to withdraw from participation in this second round type cooperative project was based on (*a*) a January report by the Commission's Division of Licensing and Regulation and the Advisory Committee on Reactor Safeguards (ACRS) in which the committee reiterated that it had extreme doubts that clarification of unknown factors relating to the hydrological and meteorological aspects of the proposed Haskell Canyon site in Los Angeles County would make it prudent for use as a site for a larger nuclear power complex than the proposed plant;[2] and (*b*) a higher estimated cost of power from the plant than was anticipated at the time the proposal was submitted to the Commission. In view of the action by the proposer, the Commission withdrew the proposed basis for contractual arrangements which had been submitted to the Joint Committee on Atomic Energy in November 1960. Considerations then were begun on alternate courses of action regarding this project.

[2] The two cities had indicated that they expected to locate eventually more than one reactor at the site. The Advisory Committee on Reactor Safeguards, in a previous letter to the Commission dated June 8, 1960, concluded that the site is suitable "for a 50 MW(e) boiling water reactor which follows existing technology". The letter further stated "The Committee has doubts whether this site can be safely expanded into a large power complex."

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airyland offer. On April 10, the Dairyland Power Cooperative of aCrosse, Wis., which had been negotiating with the Commission egarding the Small Pressurized Water Reactor, and which had also xpressed interest in the Prototype Organic Power Reactor, expressed interest in cooperating in the 50,000 ekw ICBWR reactor project. airyland suggested a site at Genoa, Wis., the same site which had een found acceptable by the Advisory Committee on Reactor Safeuards in connection with the Prototype Organic Reactor.

After negotiation on this unsolicited proposal, the Commission anounced on June 6 that substantial agreement as to contractual arangements for a cooperative project under second round terms had een reached with Dairyland and with Allis-Chalmers Mfg. Co., hich had been selected as reactor constructor under the previous rrangement with the Cities of Los Angeles and Pasadena. The roject, formerly referred to as the *Improved Cycle Boiling Water Reactor*, was re-designated the *LaCrosse Boiling Water Reactor*, ith the same capacity of 50,000 ekw. The basis for the proposed ontract was negotiated and submitted to the Joint Committee on tomic Energy with a request that authorization for the project rrangements be included in the Commission's fiscal year 1962 auorization. The bill was approved in September.

Execution of the Commission's contracts with Dairyland and Allisalmers awaits completion of review and approval by the Rural lectrification Administration (financing organization for Dairyand) and approval by the U.S. Army Corps of Engineers for dredgg and construction of a dike on the east bank of the Mississippi iver. Under the contract arrangements, Dairyland would provide turbogenerator and the site, operate the plant for the Commission r 10 years, and purchase the steam produced by the reactor. Allisalmers would design and construct the reactor, including the first ew, train operating personnel, and perform necessary pre-acceptance erating tests, under a contract with a fixed price of approximately 8 million.

illecitos Boiling Water Reactor (VBWR)

The 5,000 ekw privately owned boiling water reactor near Pleasnton, Calif., was shut down in January by the General Electric Co. permit replacement of cracked components made of 17–4 PH stainss steel and to perform other reactor modification. The Commission aluated the changes in components and design and determined that actor operation could be resumed with the understanding that cerin periodic tests and inspections are made of the control rod drive stem.

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The *VBWR* continued supplying electricity for the San Francisco Bay area through the generating equipment of the Pacific Gas and Electric Co. while, at the same time, the reactor was used for obtaining data related to advanced reactor technology such as high power density cores.

Dresden Nuclear Power Station

The privately owned 180,000 ekw Dresden plant of the Commonwealth Edison Co. remained shut down at Morris, Ill., from November 15, 1960, through May 1961, for replacement of the cracked 17–4 PH stainless steel components of the control rod mechanisms and for other repair. Cracks had been found in the control rod material while the reactor was shut down because a control rod had separated from its drive mechanism. While this replacement work was underway in February, numerous cracks were also discovered in the boron-stainless steel control rod blades, and a decision was made to replace all 80 of the control rod blades.

Hairline cracks were also found adjacent to some of the welds on the lower support grid of the reactor. Reactor operation was resumed at the beginning of June. The Dresden plant then operated at, or close to, design power until it was shut down on October 3 for a two-month period to inspect in-core reactor measurements and to perform scheduled maintenance. Inspection showed the condition of the core to be unchanged from the time of the previous inspection in April. No new evidence of cracking was noticed. Thus, the steady high power operation of the Dresden reactor from June to October apparently had no adverse effect on the core support structure and it appeared entirely safe for continued operation. The reactor was started up again on December 6, and by the end of the year had generated a total of 830,750,000 kilowatt hours of electricity.

Humboldt Bay Power Plant

Construction proceeded as scheduled on the 48,500 ekw, privately owned boiling water plant of the Pacific Gas and Electric Co. near Eureka, Calif. The reactor vessel was delivered and installed in October. Construction started in November 1960, and should be complete in July 1962. By the end of 1961 it was 50 percent complete.

This reactor will employ natural convection circulation of the coolant. The external containment is of the vapor suppression type, located primarily below ground level. In this containment concept, steam that might be released by rupture of the reactor vessel would be conducted through numerous large diameter pipes into a pool of

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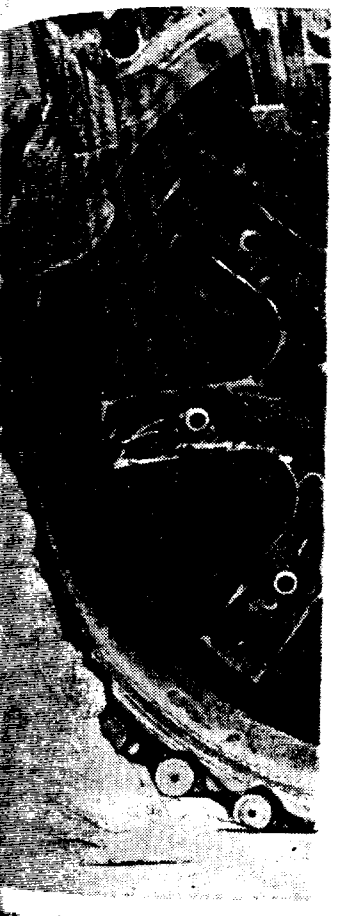

RAX—5 *Pressure Vessel.*
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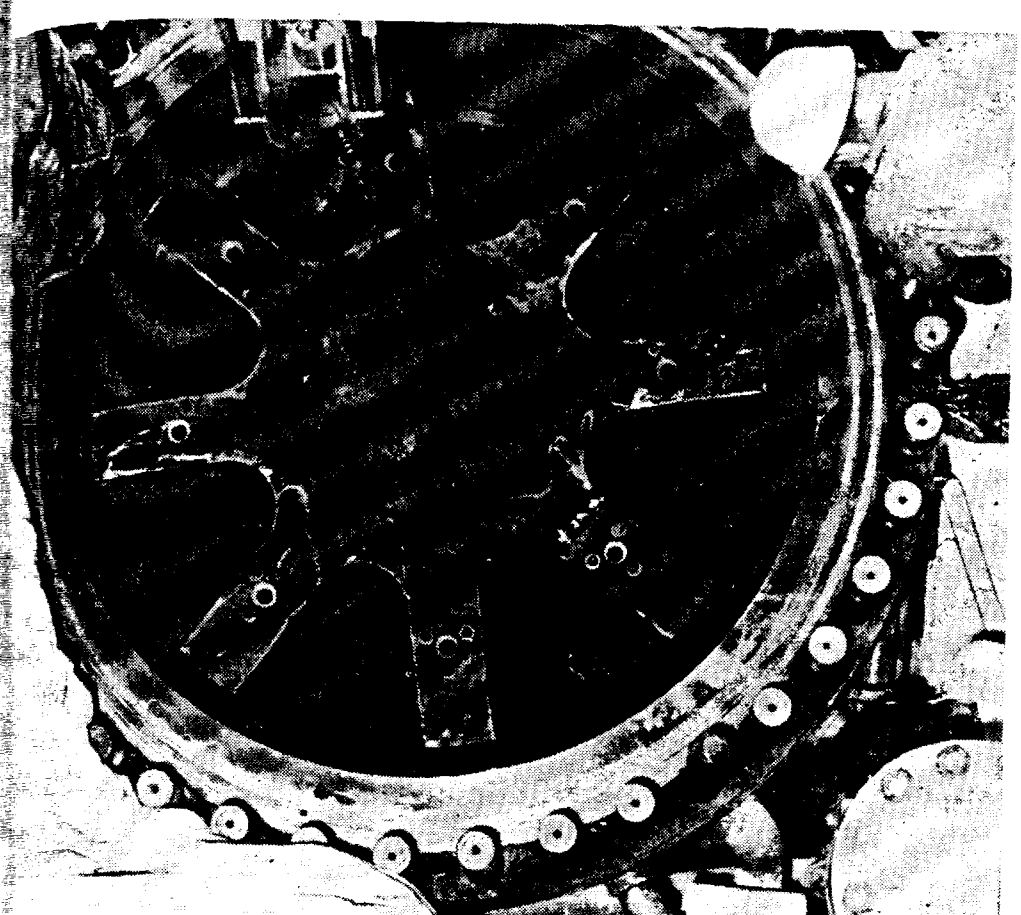
ater where condensation of the steam would take place. Thus, the ressure which would tend to drive concomitantly released radioac- ity into the environment would be removed.

dega Bay Reactor

The Pacific Gas and Electric Co. announced in June that it intended build an atomic power plant of 313,000 ekw capacity at Bodega y, about 50 miles north of San Francisco. If necessary informa- n can be developed for support of requests for licenses and permits ich the company expects to make early in 1962, plans are for con- ction to start about August 1962, with completion expected before end of 1965. Government financial assistance for this plant has been requested. The reactor will be a forced circulation, internal eam separation, single-cycle boiling water reactor utilizing a vapor ppression containment system similar to that in the Humboldt Bay ctor.



II–5 Pressure Vessel. Fifth in the series of Boiling Reactor Experiments AX) being conducted by the Commission, the BORAX–5 is designed to the feasibility of a reactor core producing saturated steam which is subse- y superheated within the same core. Photo shows the interior of the r's pressure vessel into which a measuring "spider" is being lowered to de- e the exact internal dimensions of the core. Superheat core criticality ted in early 1962.

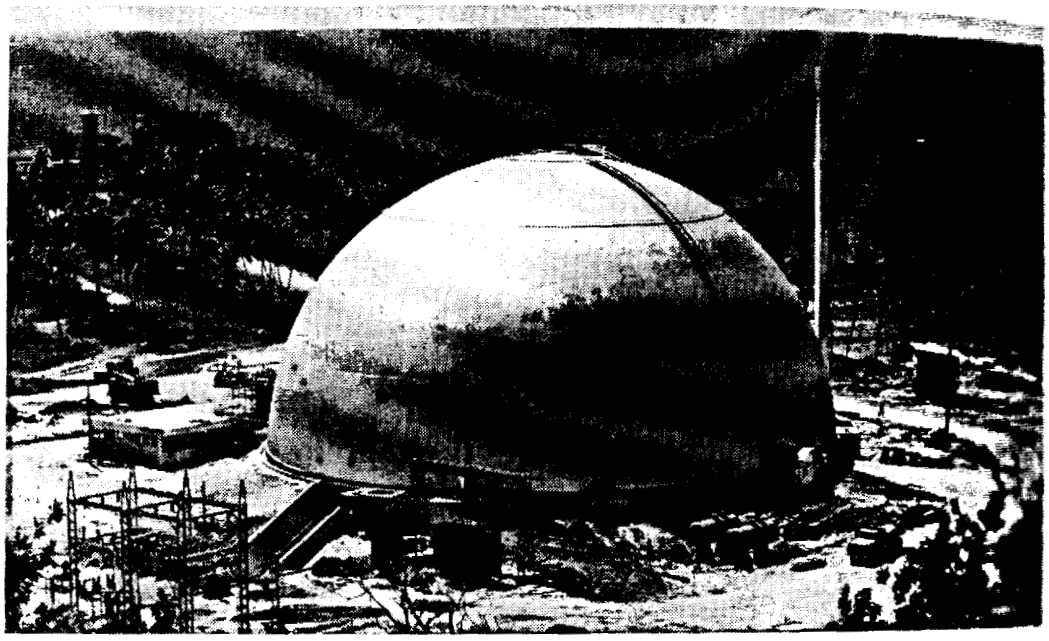
5007229

Nuclear Superheat Reactors

Boiling Reactor Experiment No. 5 (BORAX-5)

General plant construction of *BORAX-5*, the fifth in the series of Commission-financed boiling reactor experiments carried out by the Argonne National Laboratory (ANL), was essentially completed by March at the National Reactor Testing Station (NRTS) in Idaho. However, the superheat program of BORAX-5 was set back several months when the first fuel plates for the superheat core were rejected because they did not meet Argonne specifications. Work went forward on other aspects of the plant and criticality in the boiling core is expected in early 1962. Superheat core criticality is expected shortly thereafter.

The primary objective of BORAX-5 is to demonstrate the feasibility of an integral boiling-superheating reactor, and subsequently to provide data on forced circulation, various core configurations, and void fraction for further development of the integral superheat concept. The reactor has a design power of 20 Mwt and a net electrical output of 2,650 kilowatts, but this electricity is not used.



BONUS Reactor. At year's end, the containment shell for the Boiling Nuclear Superheat (BONUS) Reactor at Punta Higuera, Puerto Rico, was completed. The 16,300 electrical kilowatt plant will demonstrate the practicality of nuclear superheat utilizing a superheater region located peripherally to the boiling core region for small reactors. The plant is being built jointly by the Commission and the Puerto Rico Water Resources Authority.

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Boiling Nuclear Superheat (*BONUS*) Reactor

At Punta Higuera, Puerto Rico, over-all construction of the 16,300 ekw *BONUS* reactor was about 45 percent completed at the end of November. The project is being carried out jointly by the Commission and the Puerto Rico Water Resources Authority as a cooperative project under a second round-type agreement. Completion of construction by the Maxon Construction Co. is scheduled for the end of 1962.

This reactor will provide information on the practicability of integral nuclear superheat, and will be of value in the evaluation of nuclear superheat for small (20,000 ekw or less) plants utilizing a centrally located boiling core region and a peripherally located superheater region.

Pathfinder Atomic Power Plant

At the end of December, construction was nearing completion of the 62,000 ekw Pathfinder plant of the Northern States Power Co. at Sioux Falls, S. Dak. Site work on the third round cooperative project began in November 1959, and initial criticality should be attained by September, 1962.

During the first quarter of 1961, the Commission modified its contract with Northern States to provide a basis for certain programmatic changes found desirable as a result of the contractor's research and engineering studies, accumulation of experience, and concurrent developments in reactor technology. These changes included: substitution of zirconium or other fuel cladding material in lieu of aluminum, and acceleration of the low enrichment superheater fuel effort. No alteration was made in the basic arrangements of the contract. The reactor will provide test and operating data on an integral boiling-superheating core with a superheater centrally located within the reactor core.

Vallecitos Experimental Superheat Reactor

In February, the General Electric Co. submitted an application for a license authorizing private construction and initial operation of 12.5 Mwt of an experimental nuclear superheat reactor at its Vallecitos Atomic Laboratory near Pleasanton, Calif. After a public hearing in June, the construction permit was issued and work began in August. The site is located immediately adjacent to the Vallecitos Boiling Water Reactor which has been in operation since 1957. Gen-

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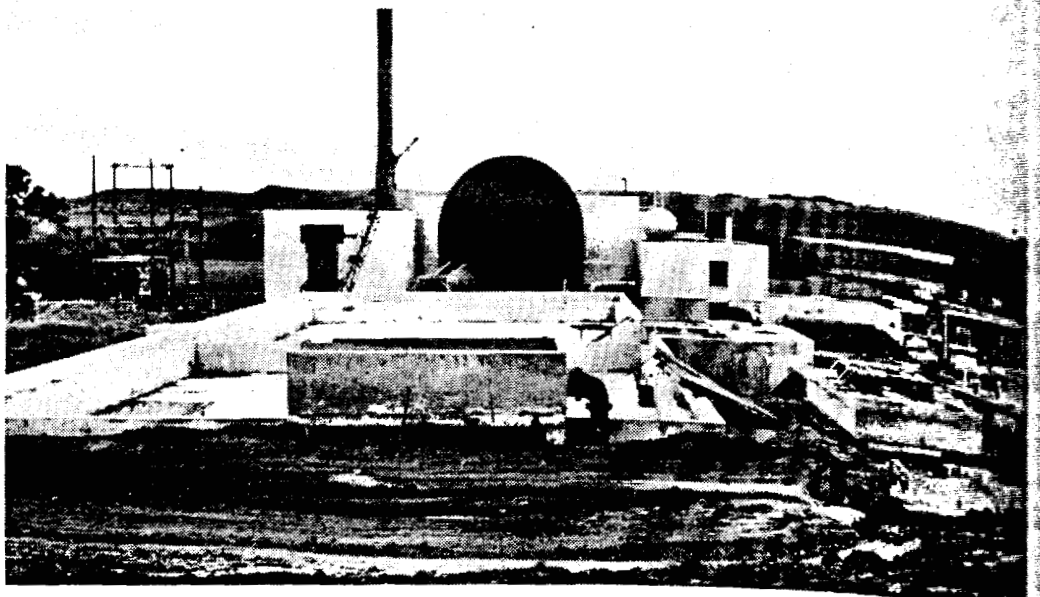

Pathfinder Plant. The 62,000 ekw Pathfinder Atomic Power Plant at Sioux Falls, S. Dak., will provide test and operating data on an integral boiling-superheating core with the superheater centrally located within the reactor core. Construction was nearly complete at the end of 1961. The plant is a Commission-Northern States Power Co. project.

eral Electric plans ultimate operation of the superheat reactor using steam produced by the VBWR. In the interim, operating experience will be accumulated by using steam produced by a gas-fired boiler. Construction is scheduled to be completed by August 1962. The objective of the experimental reactor is to test superheat reactor fuel and to improve superheat reactor performance.

Of the current estimated cost of $9 million, $5.75 million is being contributed by the seven-utility Empire State Atomic Development Associates, Inc. (*ESADA*). The Empire State group, late in 1960, announced a long-range, privately financed research program that may lead to construction of a large reactor in New York State. The ESADA has contracted with General Electric for boiling water reactor research, with General Atomic for studies on a gas-cooled reactor, and with Atomics International for sodium-cooled reactor fuel technology. This is a part of ESADA's program aimed at establishing a sound basis for the design of a full-scale atomic power plant that would be competitive in New York State before the close of the present decade.

5007232

Organic Cooled Reactors

ganic Moderated Reactor Experiment (OMRE)

The Commission's *OMRE* has been in operation at the National actor Testing Station since 1957 and is now on its third core load- Operation of the OMRE on its second core was completed in rch 1960, and since that time extensive investigation and testing been performed as a result of the fuel element surface fouling ountered in Core 2 operation. Atomics International, Phillips troleum Co., and California Research Corp. have been conducting arch and development on the fouling problem, which results from formation of a film on fuel elements by decomposed coolant and rganic particles from the coolant. It is expected that the fuel ment fouling question will be resolved when data from tests now in gress becomes available in the summer of 1962.

After the third core was loaded, critical experiments were begun September 1960, but power operation was not initiated until July 1. In the interim the reactor system and method of operation was dified to permit more flexibility. This work included the addition filters and use of the continuous purification system.

The third core contains three types of fuel elements. Included are highly enriched stainless steel uranium oxide driver elements, minum-clad uranium alloy elements, and APM (aluminum powder allurgy) clad uranium dioxide elements. The latter type is ned for use in the proposed 50,000 ekw Prototype Organic Power tor. It is expected that the third OMRE core will be replaced slightly enriched, aluminum-clad, uranium alloy core loading in 1962, but that the APM-oxide fuel elements will be continued er test for about 2½ years.

erimental Organic Cooled Reactor (EOCR)

The *EOCR* is a Commission experimental facility now under con- ction at NRTS, Idaho, designed to supplement operating data ided by the OMRE and to develop improvements for future nic reactors. It will have a 40 Mwt capability, but will not ice electricity. Construction progress was slowed during the because of a temporary suspension of procurement activities ing a review of an increased project cost estimate. The project ated cost has increased by $1.8 million from the previous estimate million. At the end of December construction was about 70 nt complete. Construction completion is expected by the summer 2. Operation of the reactor prior to installation of the in-pile is being considered. Congressional authorization for these loops eived in September.

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Piqua Nuclear Power Facility

Construction progress of the 11,400 ekw organic cooled and moderated reactor at Piqua, Ohio, was delayed at times by labor union strikes and construction difficulties. The second-round cooperative project is scheduled to be essentially complete in January 1962. Initial criticality is expected in March 1962 with design power operation shortly thereafter. Atomics International designed and constructed the plant for the Commission. The City of Piqua will operate it, with the steam generated being used in an existing city-owned power station.

This reactor will demonstrate the current degree of technical and economic feasibility of a small organic reactor and will provide valuable data on metallic fuel element lifetime and fuel costs. It will be the first operating organic power reactor integrated into an electric utility station.

Prototype Organic Power Reactor

In December 1960, the Commission invited expressions of interest from cooperatively and publicly owned utilities for participation in second round Power Demonstration Reactor Program arrangements for construction of a 50,000 ekw organic cooled and moderated reactor. (A previous, third-round type of invitation had elicited no responses.)

Nine expressions were received by February and staff evaluation found that four were particularly promising. The sites of these four utilities were reviewed by the Advisory Committee on Reactor Safeguards and were found suitable.

However, when the Commission extended a formal invitation to the utilities to submit definitive proposals for participation in the project, only one proposal was received—that being from the Grand River Dam Authority, Vinita, Okla. Two of the previously interested utilities, the Burlington Electric Light Department, Burlington, Vt., and the Plains Electric Generation and Transmission Cooperative, Inc., Albuquerque, N. Mex., had changed their plans and advised the Commission that they would not submit proposals. Another, the Dairyland Power Cooperative of La Crosse, Wis., did not submit a proposal because in the interim it had committed itself to cooperate with the Commission on a boiling water project.

It was found after evaluation of the proposal received from Grand River Dam Authority that it did not satisfactorily meet the terms of the invitation. The Commission has deferred further action on construction of the reactor in view of the President's request to postpone the initiation of deferrable projects.

Atomic Fuel Loader. Phot
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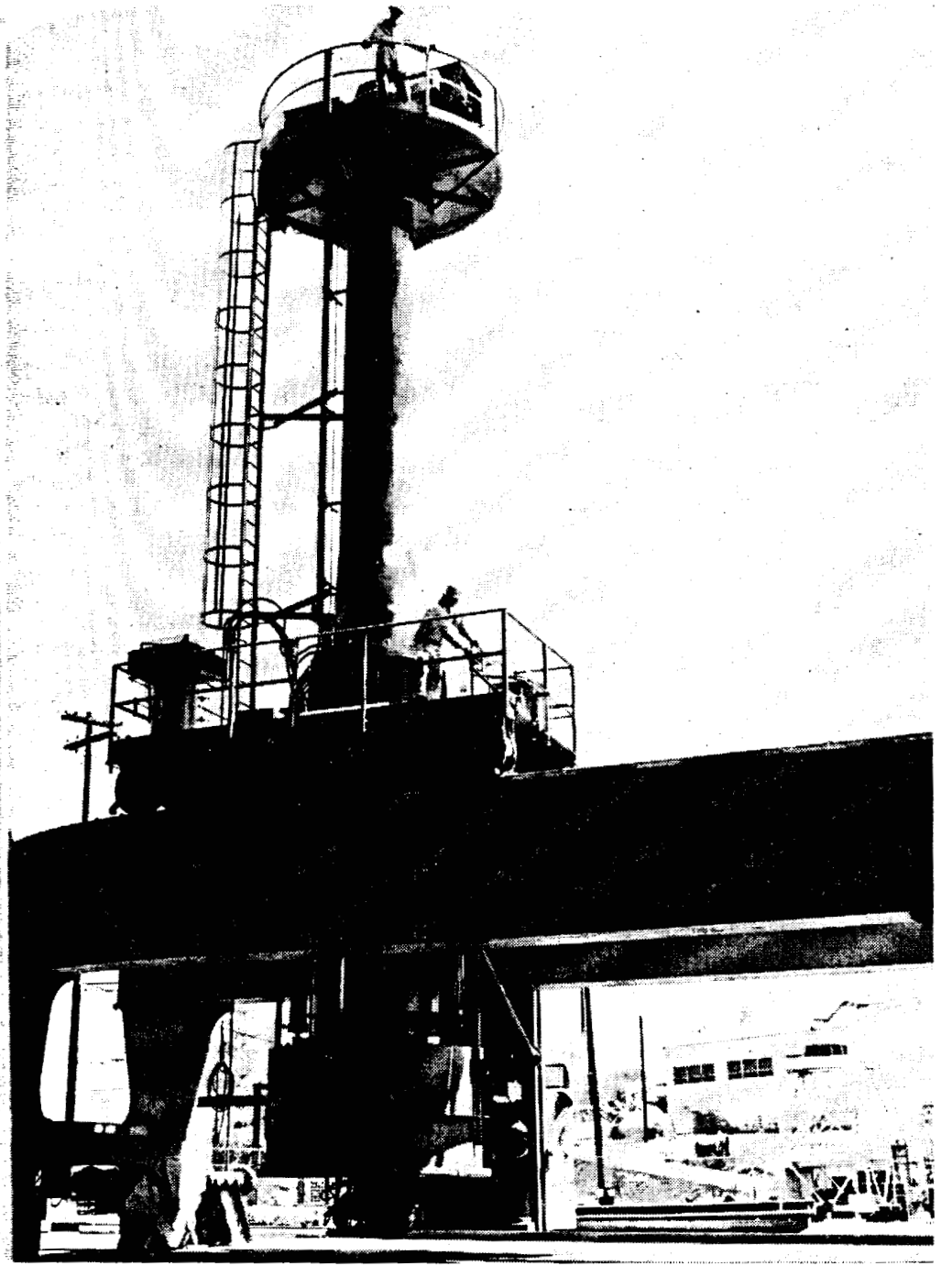


mic Fuel Loader. Photo shows the giant fuel handling cask developed for the mission by Atomics International being tested at the Sodium Reactor Experi- (SRE) site, Santa Susana, Calif., before being dismantled and shipped to lam, Nebr. The 54-foot high machine will handle and load reactor compo- 40 feet long for the 75,000 kilowatt sodium-cooled, graphite-moderated otype Hallam Nuclear Power Facility.

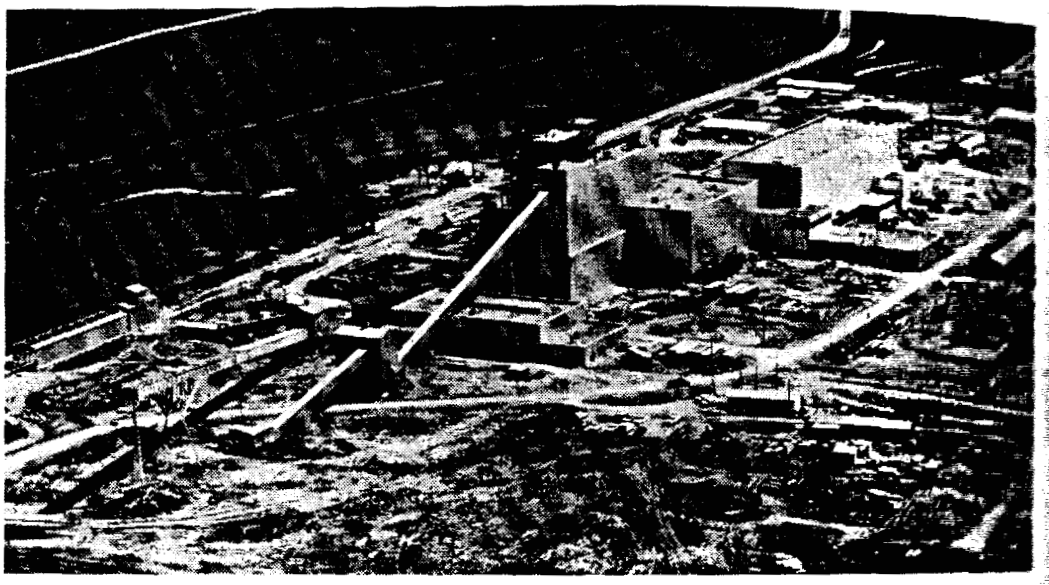
5007235

Sodium-Cooled Thermal Reactors

Sodium Reactor Experiment (SRE)

The *SRE* at Santa Susana, Calif., has been operated as an experiment since 1957 for the Commission by Atomics International. Since attaining criticality with a second fuel loading of thorium-uranium alloy in September 1960, operation of the 5,000 ekw reactor has been directed toward solution of an unexpected positive power coefficient effect caused by thermal bowing of the fuel rods. In the last quarter of 1961, the positive power coefficient was successfully eliminated by mechanically stiffening each fuel assembly. As of December 31, the total electrical generation on the second core was 862,690 kilowatt hours.

Design to cover systems modifications necessary to increase the thermal power level from 20 to 45 megawatts and to permit operation at 1,200° F. is underway. A firm schedule for completion of the modification has not been established. These modifications will not be performed until the reactor has demonstrated reliability by operating at design power for a sustained period of time.



Hallam Project. The 75,000 electrical kilowatt nuclear power facility being built near Hallam, Nebr., by the Commission and Consumers Public Power District of Nebraska, is scheduled to begin producing power by mid-1962. The sodium-cooled, graphite-moderated prototype reactor, designed by Atomics International, is housed in the large square building on the right. The buildings on the left are a coal-fired generating plant being built by the utility district.

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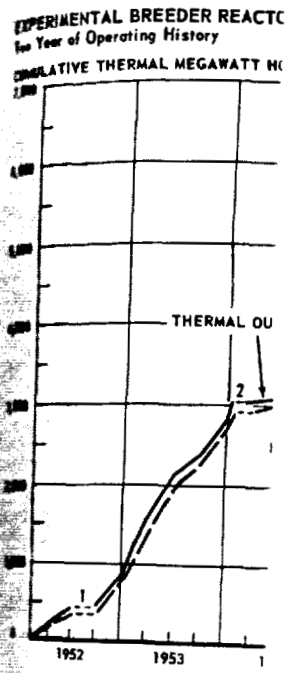

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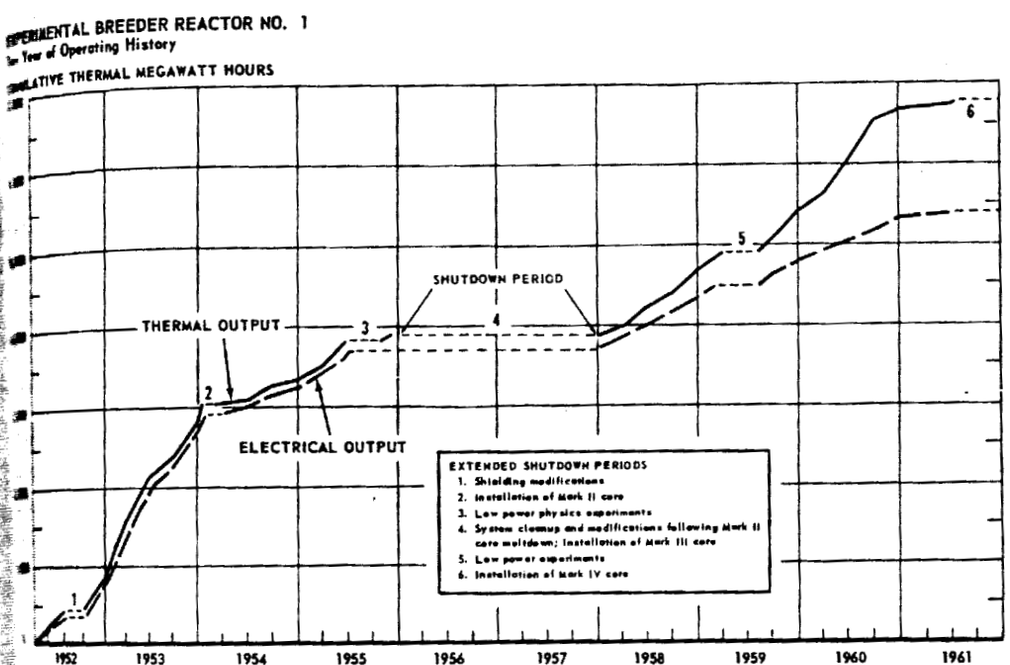
Hallam Nuclear Power Facility

Construction of the 75,000 ekw sodium-cooled, graphite-moderated plant at Hallam, Nebr., was completed in December. The plant is undergoing pre-operational testing and is expected to be in operation by mid-1962. Although the construction schedule was disrupted in mid-year by a strike of the laborers' union, a two-shift schedule with an extended workweek was instituted by the prime contractor, Peter Kiewit and Sons Co., and resulted in the first-round cooperative project being completed on schedule.

This reactor will supply power to the distribution system of the Consumers Public Power District of Nebraska, which will operate the Commission facility and utilize the steam it produces. Following an extensive operational test, the reactor will begin producing power in the summer of 1962. The reactor is designed to extend the technology developed by the SRE and to demonstrate the economic and technical practicability of central station power using a reactor moderated by graphite and with sodium as the heat transfer fluid.



Sodium-Cooled Fast Reactors

Experimental Breeder Reactor No. 1 (EBR–1)

The tenth anniversary of the initial operation of the Commission's EBR–1 was attained in December. The first electric power generated by nuclear energy was produced by the EBR–1 at the National Reactor Testing Station in Idaho on December 20, 1951. Development

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of fast breeder reactors has been pressed from the start of the Civilian Power Program because of their ability to breed more fissionable material than they consume in the uranium-plutonium cycle. Since then the reactor has operated through three cores, and criticality on its Mark IV plutonium-bearing core is planned for 1962.

Practically all of the EBR–1 operating time on the Mark III core during the early part of 1961 was taken up by the training of operating personnel. The reactor was shut down in July to prepare for loading the Mark IV core. Plans for operation of the EBR–1 on the Mark IV core include reactor physics experiments and the determination of the breeding ratio.

Experimental Breeder Reactor No. 2 (EBR–2)

The Commission's *EBR–2* is an experimental fast power reactor at NRTS, Idaho, which is directed primarily at establishing the technical feasibility of fast reactors for central station power plants. It is the nation's first completely integrated nuclear power plant incorporating the reactor, sodium boiler, and fuel recycle processing plant. The use of integrated fuel reprocessing and fuel element fabrication plants will represent the first attempt to recycle fuel in any fast reactor, to process spent fuel by pyrometallurgical methods, and to fabricate fuel elements by remote control.

Construction of the generator and reactor plants was completed in August and dry criticality experiments (without the coolant) began on September 30. The sodium boiler plant was essentially completed in December. The fuel cycle facility was also essentially complete at the end of the year except for the installation of the process equipment. Design power operation of 16,500 ekw is expected to take place in the summer of 1962. The first core will use fuel heavily enriched in uranium 235; the second core will use plutonium.

Enrico Fermi Atomic Power Plant

The Fermi Fast Reactor under construction near Monroe, Mich. was not yet completed at the end of December because of certain developmental problems which arose in the last half of the year. The completion date for this cooperative first round project of the Power Reactor Development Co. (*PRDC*) has been extended several times and is now scheduled for June, 1962. The latest delay is caused by the deterioration of graphite shielding on the reactor vessel during the 1,000° F. isothermal, non-nuclear tests.

The deterioration can be traced to oxygen leaking into the graphite region during the high temperature test and the use of resin-bound

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egrated Plant. Aerial view of the Commission's Experimental Breeder Re-tor No. 2 (EBR–II) at the National Reactor Testing Station in Idaho. e 16,500 electrical kilowatt plant will demonstrate the feasibility of reactor eration on a closed fuel-cycle. Spent fuel elements from the reactor (dome-aped building) will be transferred by remote control through an underground nnel to the processing plant (semi-circular building near tall stack) where er will be reprocessed and refabricated into fuel elements and then returned the reactor.

aphite powder instead of high quality graphite. All of this graphite being replaced.

Another problem which arose involved leaks in the No. 2 steam nerator tubes, which were noticed during hydrostatic testing. vestigation revealed that 49 of a total of 1,200 tubes exhibited cks, probably resulting from stress corrosion. The steam generator s removed and shipped to the Griscom-Russell Co. where whole es were removed for examination to determine the exact cause of e cracks and the remedial steps to be taken. It was found necessary r the steam generator to be completely retubed.

Because of fuel element design problems which came up in 1960, new subassembly for Core A was designed which overcame fuel ment distortion but inherently presents greater resistance to coolant w. In order to operate the reactor and not exceed the specified ximum fuel and cladding temperatures, the power level should exceed 200 thermal megawatts. This will lower the net electrical put from the first core to 60,000 kilowatts. PRDC originally emplated that the output of this reactor would be 94,000 ekw; k is in progress for an alternate design for later cores.

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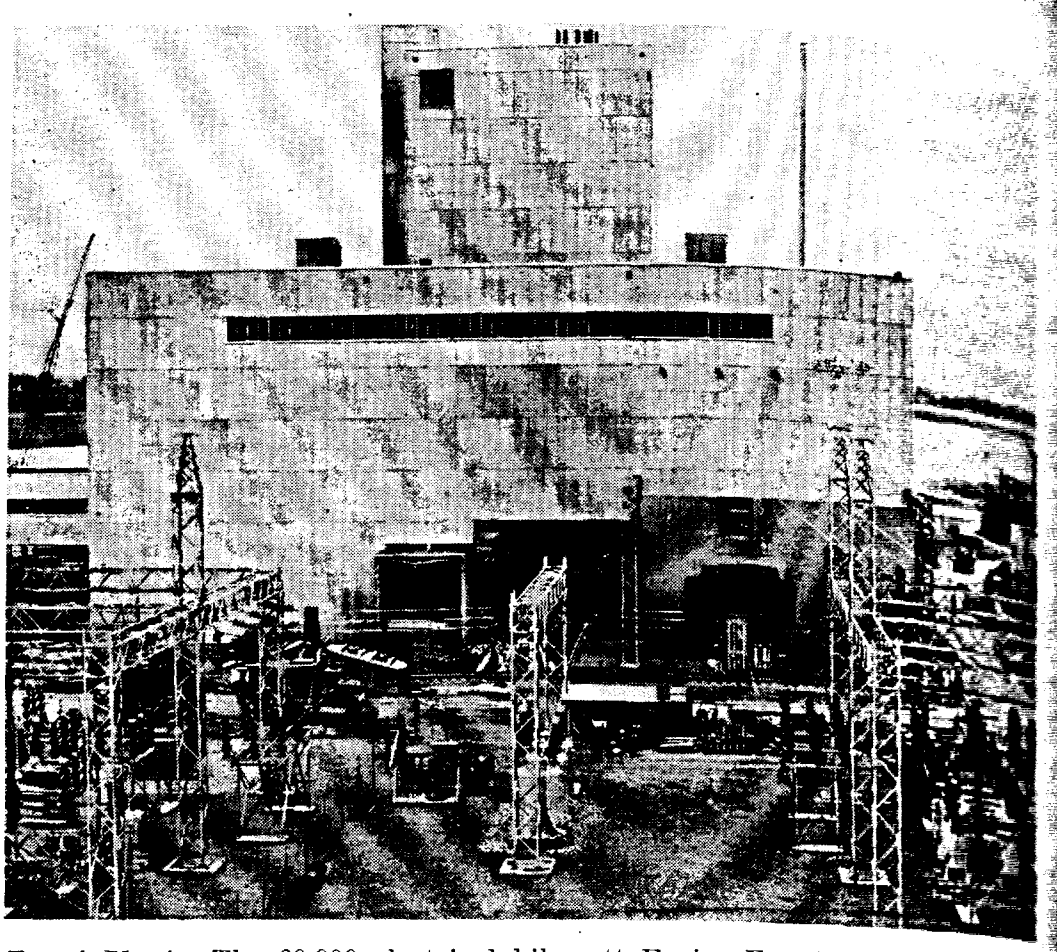

Fermi Plant. The 60,000 electrical kilowatt Enrico Fermi Power Plant near Monroe, Mich., is scheduled to begin operation late in 1962. The plant was originally scheduled to begin operation in September 1960, but technical problems have caused a series of delays in the completion of the fast breeder reactor plant. As a result of certain core modifications, the net electrical output of the plant has been reduced from the designed capacity of 94,000 kilowatts to 60,000 kilowatts.

On June 1, the Power Reactor Development Co. took over operating responsibility for the plant from the Atomic Power Development Associates, the group responsible for research and development and nuclear design.

An important legal aspect of the project was resolved on June 12, 1961, when the 1960 decision of the United States Court of Appeals of the District of Columbia regarding the Commission's issuance of a construction permit for the Fermi Reactor was reversed by the United States Supreme Court. In a 7–2 decision, the Supreme Court upheld the validity of the construction permit issued by the Commission and rejected the contention that the Commission's safety findings were inadequate.

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Gas-Cooled Reactors

Experimental Gas-Cooled Reactor (EGCR)

Several cost and schedule problems and safety questions have been encountered in the Commission's 22,300 ekw *EGCR* project which is under construction at Oak Ridge. A number of key components are substantially behind the planned delivery schedule. At this time it appears very likely that because of higher than anticipated engineering costs and because of some changes that may be required to assure safe and dependable operation, the construction cost will exceed the current estimate of $40 million. It is also expected that the reactor will not be completed until May 1963, compared to the established schedule date of October 1962. Construction of the reactor was about [illegible] percent complete at the end of December.

The EGCR will provide the earliest experience in the United States with a high temperature gas-cooled reactor system for civilian power. It will provide operating experience with materials and components applicable to advanced gas-cooled reactor systems. These include helium as a coolant, graphite as a moderator, fuel handling and servicing machinery designed for use during full power operation, dynamic shaft seals for the main blowers, and a coolant cleanup system. The reactor also has flexibility for testing a variety of fuel designs in the regular channels and provision for future installation of large volume, high temperature loops.

High Temperature Gas-Cooled Reactor (HTGR)

Start of construction of the 40,000 ekw *HTGR* at Peach Bottom, Pa., was delayed beyond the originally scheduled date of April 1961, when the Commission required additional information from the research and development effort before a construction permit could be issued to the Philadelphia Electric Co.

In August, Philadelphia Electric submitted a revised preliminary hazards report incorporating additional information obtained in the research and development effort being carried out by General Atomic Division of General Dynamics Corp. The revised report described a number of important design changes made in the interest of plant safety of this third round cooperative project. These design modifications include the addition of new emergency shutdown rods, redesign of the fuel elements, an increase in thorium loading, and the addition of an emergency cooling system.

Another significant factor in the 1961 General Atomic research and development effort has been the rapid development of coated

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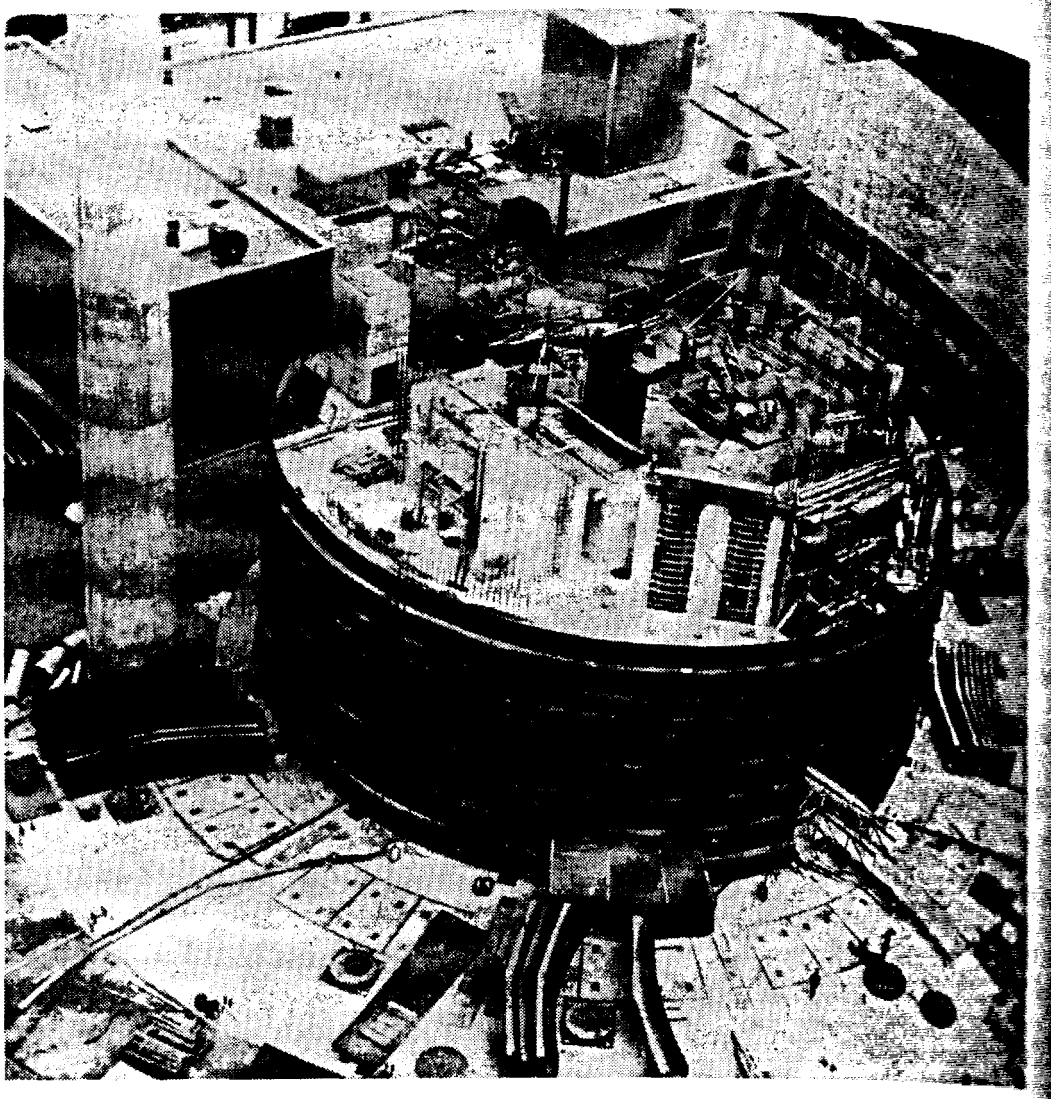

Gas Cooled Reactor. The nation's first major gas cooled nuclear power plant is now under construction at the Commission's Oak Ridge National Laboratory. Photo shows the containment shell being erected, and some of the internal construction associated with the Experimental Gas Cooled Reactor (EGCR). The reactor itself will be located below the ground level. The 22,300 electrical kilowatt plant will be operated for the Commission by the Tennessee Valley Authority when completed in early 1963. Buildings in upper portion of photo will house the turbogenerators, controls, and associated equipment.

particle fuel for the HTGR. This fuel consists of 100–400 microns particles of uranium carbide-thorium carbide, coated with 50–60 microns of pyrolytically deposited graphite, and dispersed in a graphite matrix. The particle coating serves to protect the fuel material from corrosive reaction during fabrication and to delay substantially the release of fission products generated in the fuel. Satisfactory fabrication techniques have been developed and, based on the favorable results of extensive tests, this fuel will be used in the first core of the HTGR.

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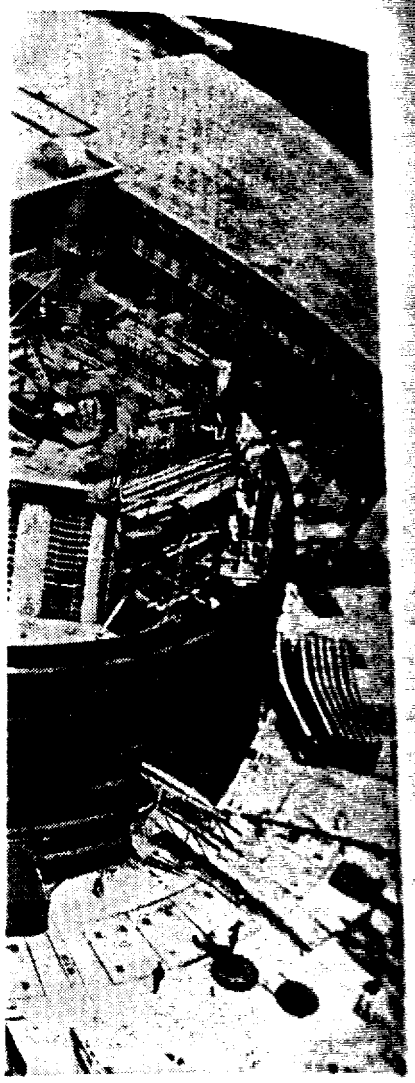

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The revised preliminary hazards report on the HTGR has been reviewed by the Commission staff and by the Advisory Committee on Reactor Safeguards. The conclusion was that the proposed reactor can be constructed at the Peach Bottom site with reasonable assurance that it can be operated without undue risk to the health and safety of the public. A public hearing on this project was held at Commission Headquarters on December 18 and at year's end the Hearing Examiner's decision on the issuance of a construction permit was pending.

Exchange Agreements on Gas Cooled Reactors

The exchange of information on gas-cooled reactors was continued between the United States and the United Kingdom during 1961. Semiannual meetings were held in April in England, and during October in the United States, concerning the HTGR and the DRAGON project, a high temperature gas cooled reactor being built at Winfrith Heath, England. An organization of several West European nations participating with Great Britain in the DRAGON project. DRAGON has been under construction for a year.

The exchange of technical information between the EGCR at Oak Ridge and Britain's Advanced Gas Cooled Reactor is handled through two permanent committees, one in England and one in the United States. Both this and the HTGR-DRAGON exchange continue to function actively and are of mutual benefit.

Heavy Water Reactors

Florida West Coast Reactor

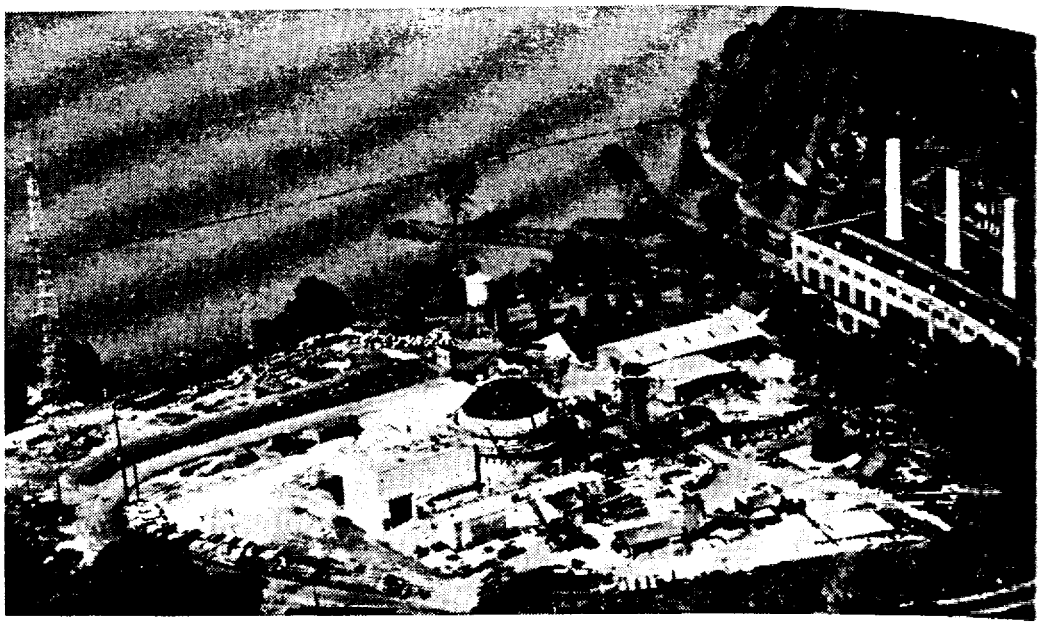
The 50,000 ekw gas-cooled, heavy water reactor project that had been proposed for construction in Polk County, Fla., was terminated in mid-[illegible] because of technical and economic uncertainties.

On February 14, the Commission was notified by the East Central Florida West Coast Nuclear Groups that it was not feasible to make a proposal containing a firm commitment to construct the proposed prototype reactor in western Florida. Essentially, the two groups requested a continuation of the research and development program for an additional two years in order to clarify technical and economic uncertainties about the reactor system. After evaluating the [illegible] and meeting with representatives of the two groups, the Commission concluded that it should terminate the present project for a

gas-cooled, heavy water moderated reactor. A proposed amendment to the contract terminating the project was submitted to the Joint Committee on Atomic Energy during May 1961.

In order that participation of the groups might not be lost to the civilian power program, the Commission proposed that the companies continue to explore natural uranium reactor systems which might be of mutual interest to the companies and the Commission.

The East Coast Nuclear Group has agreed to evaluate the relative merits of boiling and pressurized heavy water and high pressure gas-cooled heavy water systems from a utility point of view. The evaluation will be based upon information furnished by the Commission from its reactor development program.



South Carolina Project. The 17,000 electrical kilowatt heavy water moderated and cooled, pressure tube reactor being built at Parr, S.C., is expected to achieve criticality during August 1962. Photo was taken in September 1961, shortly after the 65-ton metal dome (center of photo) had been emplaced on the containment shell. The cooperative plant is being built near an existing conventional generating station by Carolinas Virginia Nuclear Power Associates.

Carolinas Virginia Tube Reactor (CVTR)

Plant construction of the 17,000 ekw heavy water moderated and cooled, pressure tube reactor was progressing as scheduled at Parr, S.C., and by the end of December was about 75 percent complete. Criticality of the *CVTR* is expected by August 1962. Westinghouse Electric Corp. is responsible for research and development and Daniel Construction Co. is doing the construction.

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This reactor, being constructed by the Carolinas Virginia Nuclear Power Associates under a third round cooperative arrangement, eliminates the large pressure vessel generally used for pressurized water reactors. The CVTR will have zircaloy U-shaped tubes to contain individual fuel elements and pressurized coolant; the cold, heavy water moderator will surround the tubes and be contained in a single, low-pressure tank.

During 1961, irradiation tests indicated that it will be possible to extract more power from the CVTR per foot of fuel element than was originally calculated. Experiments confirmed that the design power of 17,000 ekw can be achieved with 72 instead of 84 fuel elements, which permits the elimination of six pressure U-tubes.

Heavy Water Components Test Reactor (HWCTR)

The *HWCTR* is being built as a Commission project to test components for a heavy water power reactor. This 61 thermal megawatt facility was designed and is being constructed by E. I. du Pont de Nemours and Co. at the Commission's Savannah River Plant, near Aiken, S.C. The reactor vessel, which had been delayed in fabrication for almost a year, was delivered to the site in June. Construction progress then increased and at the end of December the reactor was essentially complete. Initial criticality of this heavy water moderated and cooled, pressure vessel type reactor should take place in February, 1962.

Early in 1961 the du Pont Co. reviewed the design of the control and safety rod drives of this reactor to determine how to eliminate the possibility of stress cracking of 17–4 PH stainless steel which has occurred in other reactors using this material. It was decided to continue use of 17–4 PH stainless steel, but to employ heat treatment of the units at 1,100° F. instead of 900° F.

The HWCTR is designed to permit simultaneous test irradiation up to 12 full-sized natural uranium fuel elements at power ratings and exposures encountered in full-scale power reactors. Both uranium metal and oxide fuel elements of various sizes and shapes will be used. There is no provision for generation of electric power. Heat will be dissipated to the atmosphere through a light water secondary system.

Plutonium Recycle Test Reactor (PRTR)

The objective of the Commission's plutonium recycle experimental program as carried out at Hanford, Wash., is to demonstrate the feasi-

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bility of recycling plutonium as an alternative or supplement to uranium 235 fuel in thermal heterogeneous reactor systems. Successful completion of the program will permit construction of power reactor systems capable of producing three to four times as much power from a given quantity of natural uranium, or even somewhat depleted uranium, as would be possible without recycling.

The *PRTR*, a heavy water moderated and cooled pressure tube type of reactor, attained initial criticality in November 1960, but power testing was interrupted for several weeks while corrosion and operating problems were corrected. After progressing through a series of step increases in power level, full power of 70 megawatts, thermal, was achieved for the first time on July 21, 1961. Performance of the scheduled power tests then continued at various power levels. During the latter half of the year, a great deal of effort was expended on correcting such difficulties as the excessive losses of helium and heavy water and the unsatisfactory operation of several plant components.

Canadian Cooperative Program

Both the United States and Canada are pursuing programs for the development of heavy water power reactors. A cooperative program between the two countries was entered into during June 1960, under which it was agreed that information would be exchanged in sufficient detail to enable either country to design, construct, and operate such reactors. Information is exchanged through reports, periodic meetings, and the assignment of personnel from each country to participate actively in the reactor program of the other country. In addition, the United States is undertaking a research and development program which is being carried on by American contractors in support of the Canadian reactor effort.

Examples of this work include the development of an on-power refueling machine, performance of containment studies, development of a metallurgically bonded stainless steel-zirconium joint, testing of heat exchangers at operating conditions, development of ultrasonic methods for non-destructive testing of zirconium tubing, and performance of a computer study for stability and control of CANDU—designation for the 200,000 ekw Canadian deuterium moderated and cooled, natural uranium-fueled reactor under construction at Douglas Point on the Canadian shore of Lake Huron.

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Fluid Fuel Reactors

Aqueous Homogeneous Concept

Work on the Commission's experimental aqueous homogeneous reactor concept was terminated on June 30, the end of fiscal year 1961. A number of factors contributed to the decision to terminate work on the concept despite its potential for thermal breeding and the low estimated cost of the fuel cycle. Included in the factors were: (*a*) the potential of the aqueous homogeneous reactor system to achieve competitive nuclear power within a reasonable period of time did not appear as good as that of other systems being developed; (*b*) a large-scale continuing program involving an expenditure of at least $100 million would be required to complete the development of the concept; and (*c*) the need for the development of breeder reactors, while important, is a long-term effort. Some research on aqueous systems will be continued under the Thorium Utilization Program which was initiated at Oak Ridge during the latter half of 1961.

Homogeneous Reactor Experiment No. 2 (HRE–2)

Operations with the *HRE*–2 at Oak Ridge were terminated as planned on April 28 as part of the close-out of this reactor concept. The HRE–2 had been operated since December 1957 as an aqueous homogeneous experiment to provide nuclear data as well as to determine whether the advantages inherent in the simplicity and low cost of the liquid fuel cycle might outweigh the technical complexities of the system. During the operation of the HRE–2, holes developed in the core vessel, allowing fuel to move between the core and the blanket region. The holes resulted from uranium-bearing solids settling against the core wall and causing local overheating. During 1960, the holes in the core vessel were patched and the flow through the core vessel was reversed to reduce the possibility of fuel instability and local overheating.

Since November 1960, when operation with reversed flow was begun, more than 500 hours of operation were recorded at power levels greater than 3.5 Mwt and at an operating pressure of 1,400 psi. During this time there was no detectable instability of the fuel solution. However, there was an unscheduled increase in average nuclear temperature during the last week of operation, and after completion of the scheduled shutdown, inspection revealed that one of the core patches had failed. After flushing out the system and other close-out procedures, the HRE–2 was placed in storage in an assembled state. During the last part of 1961 metal specimens from various parts of the

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system and a number of failed components were examined. Final reports were prepared covering all important phases of HRE-2 operation and other research and development factors in the program which could be of aid to any future study of this concept.

Molten Salt Reactor Experiment (MSRE)

Much of the previous effort on fluid fuel systems at Oak Ridge is now being concentrated on the molten salt system. The molten salt reactor concept has a number of attractive features including high temperature, low pressure, good neutron economy, low fuel cycle cost, and high power density and specific power. Based on the promising results of research and development work which has been underway for a number of years, facility modification preparatory to construction of a 10 Mwt molten salt reactor experiment (*MSRE*) was started early in May by the Oak Ridge National Laboratory and the H. K. Ferguson Co.

The reactor will use a mixture of molten fluoride salts as fuel and coolant. Since the fuel is in solution, no fabrication of fuel elements is necessary and continuous removal of fission poisons is possible, thereby providing good neutron economy. Solid graphite will be used as a moderator. The container material is INOR-8, a nickel base alloy. No steam or electricity will be generated by the MSRE, and the heat will be dissipated to the atmosphere by means of an air-cooled heat exchanger.

The MSRE will be built in the existing Aircraft Reactor Experiment building which is being modified. The current cost estimate for the reactor is $6.5 million. During 1961, the schedule for completion of the MSRE was extended a half year, and initial criticality is now scheduled for early 1964.

Advanced Reactor Systems

Los Alamos Molten Plutonium Reactor Experiment (LAMPRE)

The Los Alamos Scientific Laboratory (LASL) is continuing its investigations of means for utilizing plutonium fuels in reactor applications. The main efforts of the reactor studies at LASL are centered about the Molten Plutonium Reactor Experiment (LAMPRE).

LAMPRE, designed for one megawatt, thermal operation, utilizes a fuel loading of about 23 kilograms of plutonium in 135 individual tantalum capsules. The coolant is sodium. In April 1961, the reactor first went critical with molten fuel and since that time has been

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ated at powers up to 40 percent of design power. The behavior the reactor has confirmed the expected inherent stability, ease of trol, and smooth response to power demand. However, LAMPRE ation has disclosed a significant loss of reactivity associated with higher powered runs, and to a lesser extent during shutdown ods. A thorough check for fuel leaks has been made and none vered. At the present time it is presumed that this reactivity is caused by gaseous fission products retained in the fuel.

LAMPRE has accumulated more than 4,000 hours of operation g molten plutonium. Fuel capsules dissected after operating for length of time disclosed no corrosive attack although it is possible full power operation will show some effects, and determining this be one of the purposes of the experiment. Additional attention ing given to the development of dilute fuels capable of application arge reactors. A series of ternary alloys are being investigated, and capsule arrangement in LAMPRE provides an excellent method investigating several fuels at once.

Operation of the LAMPRE is providing data for evaluation of the ciple of using metallic plutonium as a fuel in liquid rather than lid state. Consequently, the low melting point of metallic plu- um may be an asset rather than a liability for use in high specific er. high temperature reactors.

Construction on the Fast Core Test Facility, a flexible facility de- ed to accept, in sequence, several future cores in the Los Alamos Breeder Program, is scheduled to start in April 1962.

High Temperature Reactor Experiment (UHTREX)

Although the Commission had decided late in 1960 not to proceed construction of the 3 Mwt high temperature *Turret* reactor experi- at the Los Alamos Scientific Laboratory, further consideration review resulted in the project being reinstated into the re- program, as the Ultra High Temperature Reactor Experiment TREX).

Upon reinstatement of the project, LASL reviewed project plans concluded that there would be no major changes in the design of reactor. The rotating core and fuel loading concept was still con- ed the most advantageous for this experiment. The gas purifica- system was re-designed and considerably simplified late in 1960, this modification was retained. One design simplification which ed from the review was the elimination of control rods in movable portion of the core. Construction of the UHTREX

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test facility is scheduled to begin in April 1962. A revised schedule for the project calls for completion of construction in 1964.

Pebble Bed Reactor

Research and development at Oak Ridge National Laboratory is continuing in support of a pebble bed, gas-cooled reactor experiment of 3–10 Mwt. In this concept a stationary bed of spherical balls or pebbles of graphite containing uranium fuel is cooled by helium gas. A firm schedule and site location of the experiment have not yet been established.

The major objectives of the reactor experiment are to investigate the use of coated particle fuel and to demonstrate the unique characteristics of the pebble bed concept such as simplified fuel handling during reactor operation. Investigations are also being made into the possibilities of designing the experiment so it can later be adapted to operation at temperatures required for process heat applications such as coal gasification.

An agreement is being negotiated with the West German Government to provide for exchange of information on the respective pebble bed programs. A pebble bed type of power reactor of 6 Mwt is currently under construction in West Germany and is scheduled to be operating in 1964.

Experimental Beryllium Oxide Reactor (EBOR)

The experimental beryllium oxide reactor, designated *EBOR*, is an intermediate step toward the development of a merchant ship propulsion system consisting of a gas-cooled reactor directly coupled with a closed-cycle gas turbine. EBOR will be constructed at the National Reactor Testing Station. The former Aircraft Nuclear Propulsion Shield Test Pool Facility is to be used, after modification, as the reactor site. The EBOR will have a 10 Mwt capacity, but is so designed that it can be modified later to permit operation at 50 Mwt. Construction will start in mid 1962, and initial operation is expected in the summer of 1963. Kaiser Engineers, Inc., was selected as architect-engineer for the project. The current estimated cost for the reactor is about $8 million. This concept also offers promise for central station electric power.

During the year, experiments were continued with the EBOR critical facility at the San Diego location of General Atomic, and reactor materials were tested in the high temperature gas loop at Hanford, Wash., and in the Materials Testing Reactor and Engineering Test Reactor at NRTS.

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ized Bed Reactor

Research and development on the fluidized bed concept is being ied out by the Martin Co. under Commission contract. The rtin Co. has constructed a critical facility at its Baltimore loca- but has experienced difficulty in producing the uranium oxide pellets for operation of the critical facility to the desired speci- ions. Consequently, the critical experiments necessary to ex- ne the nuclear stability of this concept have been delayed until y in 1962. The basic idea of this type of reactor is to maintain a of fissionable and fertile material in a fluidized state under tur- nt flow conditions. Water or organic liquids are considered possible fluidizers and coolants. High power density, ease of ging and discharging fuel, and uniform fuel burnup are potential antages of this system.

ctral Shift Control Reactor

Research and development work was continued by the Babcock Wilcox Co., Lynchburg, Va., toward the goal of confirming for Commission the technical feasibility and economic attractiveness e spectral shift reactor concept. This concept utilizes a mixture eavy and light water as coolant in a pressurized water reactor. ation of the heavy water concentration over the lifetime of a core ing is used to change the neutron spectrum and thus control excess activity without wasting neutrons in poison shim control. Experi- al physics measurements and theoretical analyses were completed to 1 by the Babcock & Wilcox Co. for a metal-to-moderater ratio slightly enriched uranium oxide as fuel. A plant study pro- was also completed through the joint efforts of Babcock & ox and Stone & Webster Engineering Corp. to assist in the nic evaluation of the concept.

r the end of the year, Babcock & Wilcox announced their willing- construct a large spectral shift control reactor at a fixed price e nuclear portion of the plant and with certain equipment and arranties.

nced Epithermal Thorium Reactor

mics International continued operation of a privately funded al facility at Santa Susana, Calif., to investigate the reactor s of a uranium 233-thorium core operating with neutron ener- the fast range. Work on this sodium-cooled system is spon- by the Southwest Atomic Energy Associates, a group of pri-

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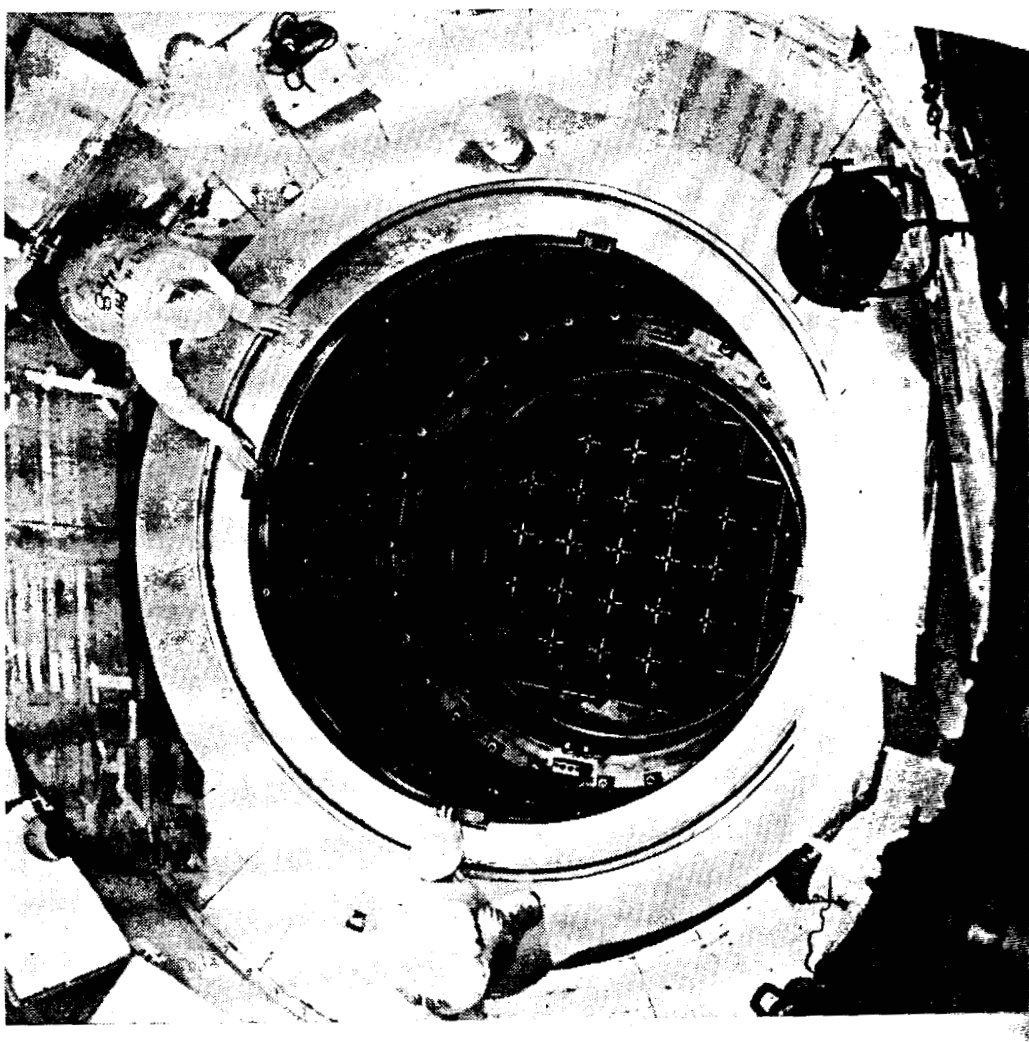
vately owned electric companies in the southwest area of the United States. The Commission has supplied 25 kilograms of uranium 235, part of which will be used for operation of the critical facility. It is expected that this type of reactor will have high operating temperatures, which provide good steam conditions and high thermal efficiency; low reactor pressure, minimizing the difficulty of vessel manufacture; compactness and high power density, with resultant low investment per unit of power in the reactor structure.



Ship's Reactor. The NS *Savannah's* reactor received its first loading of nuclear fuel on November 29, 1961. Photo shows view into the pressurized water reactor vessel prior to insertion of the fuel elements. The spacing for the 32 fuel elements can be seen between the 21 cruciform control rods already in place. The world's first nuclear merchant ship is expected to begin sea trials early in 1962. The reactor for the joint Commission-Maritime Administration project was designed and fabricated by the Babcock & Wilcox Co. A second core, which will be used as a shoreside spare, has been completed by the General Electric Co.

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Mercury Cooled Fast Reactor

Work on an advanced reactor concept using boiling mercury as the coolant in a fast breeder reactor by Advanced Technology Laboratories was terminated in mid-year by the Commission. The study of boiling mercury, interesting because of its potential use in a direct turbine cycle for obtaining a high thermal efficiency, was limited to conceptual design studies and heat transfer experiments. The design studies indicated that mercury did not offer any economic advantage over sodium as a primary reactor coolant.

MARITIME REACTORS

The Maritime Reactor Program involves research and development of maritime applications of nuclear power under the sponsorship of the Commission and the Maritime Administration of the U.S. Department of Commerce. The Commission's participation is primarily concerned only with the nuclear phases of the work, while the Maritime Administration supports associated non-nuclear developments. A joint working group of the two agencies coordinates program planning and management.

The goals of the program are to demonstrate the safety and reliability of nuclear-powered merchant ships and, through continued research and development, to obtain improved nuclear plants that will meet the requirements of ship operators.

Savannah

Construction of the world's first nuclear merchant ship, the NS *Savannah*, was completed in August at the Camden, N.J., shipyard of the New York Shipbuilding Corp. Following extensive equipment and systems check-out tests through the summer and early fall, nuclear fuel was loaded in November and first criticality of the ship's reactor was achieved on December 21. During the remainder of the year the vessel's 69 Mwt power plant underwent dockside tests at the Camden shipyard in accordance with the Commission's authorization of July 24. The authorization provided for test operation up to 10 percent of full power at Camden, after which the 22,000-ton *Savannah* will be moved by auxiliary (non-nuclear) power to Yorktown, Va., for full nuclear power dockside tests and builder's sea trials will take place.

Earlier in the year, a non-adjudicatory public hearing was held to consider the safety aspects of the *Savannah* construction and test

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program. The purpose of this proceeding, held in March and April, was to permit public participation in the Commission's review of specific safety issues. Testimony was presented by the principal contractors, the joint AEC–Maritime Group, the Commission's regulatory staff, the United States Coast Guard, the Public Health Service, and the American Bureau of Shipping. On the basis of the hearing record, Commission authorization for fuel loading and ship operation through the builder's trials stage was issued on July 24, 1961. (Further details will be found in the summary of Formal Hearings Section of Part 4 of this Report.)

Upon completion of the builder's sea trials, expected in the spring of 1962, the results of operations together with complete and detailed operating procedures, will be presented to the Commission for review and public hearing. After further approval and authorization by the Commission the vessel will be turned over to the Maritime Administration's general agent contractor, States Marine Lines, for experimental operation involving domestic and foreign port visits. During this period, the nuclear plant will be maintained and upgraded as operating experience is developed.

The Galveston, Texas, facility of the Todd Shipyards Corp. has been selected as the servicing site for the *Savannah*. Nuclear dockside facilities will be constructed there to provide for major maintenance, repair and refueling of the ship. The nuclear servicing vessel, NSV *Atomic Servant*, a non-propelled 129-foot barge equipped for the maintenance and servicing program, was delivered to the Maritime Administration during the year and turned over to Todd as part of their maintenance facilities.

The Commission's supporting research and development program for the *Savannah* was continued through the year. Fabrication of the *Savannah's* second core was completed by General Electric and zero power and kinetic tests were satisfactorily completed. Core II will serve as a shoreside spare. The projected lifetime of each *Savannah* core is estimated to be about three-and-one-half years during which the ship can travel some 300,000 nautical miles. Long-term proof and performance testing of Core I and Core II fuel continued throughout the year in the Vallecitos Boiling Water Reactor and the General Electric Test Reactor. This program provides irradiation data on the fuel well in advance of actual *Savannah* operating experience. At the end of 1961, redesign and fabrication of the spare reactor vessel head was nearing completion. The spare head will accommodate an improved control rod drive system being fabricated by the Marvel-Schebler Division of Borg-Warner Corp.

Negotiations for the acceptance in foreign ports of the *Savannah* progressed during the year. Meetings were held with representatives of various foreign governments and the European Nuclear Energy

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Association. Representatives from France and Germany visited the *Savannah* construction site at Camden and discussed acceptance of the vessel. Negotiations were continued with Norway and various other countries to obtain bilateral agreements that will permit the visit and operation of the *Savannah* in foreign waters.

Initial Loading. Working night and day in shifts, technicians used 24 hours to load 32 uranium-bearing fuel elements into the reactor of the NS *Savannah*, world's first nuclear merchant vessel. In photo above, man at right guides one fuel elements through orifice of the protective loading cover, which can be maneuvered over any area of reactor chamber. Technician at left measures radioactivity rate. Hospital-clean conditions were maintained throughout carefully rehearsed fueling procedure to prevent entry of minute foreign matter which could hamper operation of the reactor.

Advanced Maritime Developments

Developmental work was completed during the year on investigations and evaluation of improved water-cooled reactor plants. The investigations were aimed at reduction in capital costs through major design changes and reduction in operating costs through development of a highly simplified and consolidated plant. Features included in the staff studies were self-pressurization, integral pressurization, axial and radial power distribution, natural circulation, and complete load-following capabilities. Also studied during the year were multiple reactor plants for large ships and highly compact plants in pod form.

Maritime Gas-Cooled Reactors

The development of a Maritime Gas Cooled Reactor (MGCR) has been conducted by the General Atomic Division of General Dynamics Corp. under Commission contract since early 1958. The present emphasis in this program is on the design and construction of a helium gas-cooled, beryllium-oxide-moderated reactor experiment. This basic concept offers promise for use in nuclear electric power as well as maritime nuclear propulsion.

ASSOCIATED REACTOR PROGRAM ACTIVITIES

As a means of furthering the development of nuclear reactors, the Commission sponsors work in a number of areas that is of a fundamental development nature. Much of the work summarized in this section is more fully described in the Commission's supplemental report, "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Management—1961." [3]

Reactor Safety

The Commission program in reactor safety involves the use of several experimental reactor test facilities as well as research and development in reactor containment and chemical reactions.

SPERT Series

Most of the facility work is carried out at the National Reactor Testing Station where the four SPERT (Special Power Excursion Reactor Test) reactors are located. The objective of the SPERT reactors is

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

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experimental investigation and understanding of reactor kinetic avior.

SPERT–1 is a non-pressurized tank reactor which has been used for ing the six different enriched fuel cores since it began operation in y 1955.

The experimental investigation of a low enrichment (four percent) type oxide core was completed in SPERT–1 in October with a es of short period nuclear excursions terminating with a test on a millisecond period. The fuel elements for this core were previ- y used for criticality studies of the NS *Savannah* loading.

SPERT–2 has a large diameter pressure vessel capable of operating moderate pressures and temperatures under various flow conditions light or heavy water coolant-moderator combinations. Transient s were initiated in March 1960, first with light water which was r replaced with heavy water. The purpose of the heavy water tests o determine the effects of a relatively long, prompt neutron life- e upon kinetic reactor behavior. Work on transient effects at high al powers has recently been started.

SPERT–3 is a high-pressure system capable of operation at 2,500 nds per square inch, a temperature of 650° F., and 20,000 gallons minute flow conditions. It has a heat removal capacity which mits operation for short periods of time at a steady-state level of o thermal kilowatts. The reactor has a plate-type, highly en- ed, stainless steel uranium dioxide core. The two major series of er excursion experiments completed have investigated the effect of em pressure and rate of coolant flow on the kinetic behavior at room perature. One conclusion reached so far is that the ability of this em to withstand large insertions of reactivity is not affected by asing the system pressure and flow rates to the maximum.

The test schedule of the SPERT–3 was interrupted on October 26 a steam leak was observed in the pressurizer adjacent to the main ary vessel. Inspection of the pressurizer revealed a vertical crack e vessel wall 2½ inches long and ⅜-inch wide. A complete inves- ion was made to determine the cause and the corrective measures taken. The failure was discovered while SPERT–3 was in the s of a non-nuclear cold water accident test series.

SPERT–4 facility was completed in September and initial transient will begin early in 1962. It will be used first to investigate the bility behavior observed in SPERT–1. It provides a large pool se in studying open pool reactor problems and the stability of cores. Cores of reactors that have moderators other than light also can be installed and investigated in this facility.

KEWB Work Completed

The experimental phase of the Kinetic Experiments on Water Boil-ers (KEWB), designed to obtain data on dynamics of simple homo-geneous reactors, was closed out at Santa Susana, Calif., on June 30, 1961. Experiments were completed with both a spherical core and, since March 1960, a cylindrical core. Analysis of some 1,200 induced power excursions in the program, which was launched seven years ago, has shown that the homogeneous type of reactor is capable of withstanding extremely large power surges, in as short a period as 0.5 millisecond, without hazard to operating personnel and environs.

Included in the KEWB work was the study of gas formation, tem-perature, pressure, and initial core volume as related to kinetic be-havior. However, the principal accomplishment was the development of analytical kinetic models that accurately described power burst behavior and self-shutdown action for a broad range of solution type reactors.

Fast Reactor Safety

Major studies in fast reactor safety are conducted in the Transient Reactor Test (TREAT) facility at NRTS. Fast reactor safety activi-ties are largely directed to the study of fuel meltdown, a situation which might occur in fast reactors and which, conceivably, could lead to reassembly and secondary criticality. Argonne National Labora-tory has placed initial study emphasis on meltdown tests of fuel pins for the experimental Breeder Reactor No. 2 and the Enrico Fermi Fast Reactor. Oxide, carbide, and alternate fuel concepts also will be studied. Analytical studies in fast reactor safety also are being con-ducted by the United Nuclear Corp.

Other Safety Studies

Contract work on other concepts include organic reactor safety by Atomics International; gas cooled reactor safety by United Nuclear Corp.; and kinetic studies of heterogeneous water reactors by Space Technology Laboratories.

The research and development effort in reactor containment is aimed at understanding the hazards of various credible reactor accidents and also the means of restricting the hazards to the immediate vicinity of the reactor. The attempt is made in this program to predict and analyze both the degree of initial hazard and the effectiveness of con-tainment devices. Considerable work is being carried out in the na-tional laboratories, in other Government agencies, and through con-

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with industry on the general problems of containment. Major attention is devoted to the problems of defining (*1*) the energy releases associated with the maximum credible accident; (*2*) the various resulting pressure and shock loadings which must be effectively resisted by an appropriate containment system without significant loss of integrity; (*3*) the ultimate strength, resistance to load and to leakage, and the energy absorption potential of containment vessels and other components; and (*4*) improvements in currently employed methods of containment.

Research and development concerning hazardous chemical reactions is another important part of the reactor safety program. The Oak Ridge National Laboratory is systematically exploring all parameters that will provide an understanding of the major factors which affect the release of fission products when an accident causes fuel to melt in a reactor. Typical power reactor fuels, particularly uranium dioxide, are being subjected to a range of catastrophic conditions such as cladding rupture, oxidation, and meltdown.

Melting and rapid dispersion of certain metals, sometimes used in reactor construction, into the cooling medium can lead to highly exothermic chemical reactions between the metals and water. The energy released by such reactions could, in fact, exceed that released by the fission process itself during a nuclear excursion. Fortunately, the probability of extensive reactions of this kind under conditions likely to occur is very small, and large influences of very small changes in conditions of components makes such reactions difficult to study. Experimental results are usually erratic. Argonne National Laboratory has developed various ways to study metal-water reactions as well as metal oxidation ignition.

Test Irradiation Services

The Commission's needs for testing new and untried reactor fuel materials as well as reactor structural materials, moderators, and coolants has been met by use of the Materials Testing Reactor (MTR) which went critical in 1952, and the Engineering Test Reactor (ETR) which began operation in 1957. Both are located at the National Reactor Testing Station (NRTS) in Idaho. The Commission also has contracted for use of the privately owned Westinghouse Test Reactor (WTR) at Waltz Mill, Pa., and the General Electric Test Reactor (GETR) at Pleasanton, Calif.

Advanced Test Reactor (ATR)

In 1960, and as modified in 1961, Congressional authorization was obtained to construct another test reactor, one which would be capable

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of producing neutron fluxes of greater intensity than those obtainable in the MTR and ETR. This new project is the 250 thermal megawatt Advanced Test Reactor (*ATR*), which is designed to provide thermal neutron fluxes of above 5×10^{14} and epithermal fluxes of better than 10^{15} in a number of in-pile loops. These loops will provide the advanced test conditions required primarily by naval and civilian reactor programs for development of improved high performance reactor fuels and materials.

Construction of the ATR was scheduled to start at the National Reactor Testing Station in the spring of 1961, but design and potential hazards problems delayed the project. The requirement for the ATR was also re-examined in light of the cancellation of the Aircraft Nuclear Propulsion program and the resulting release of test irradiation space in the ETR. Site construction began in December and the present schedule calls for completion in late 1964.

The architect-engineer for the ATR is Ebasco Services, Inc.; reactor design has been subcontracted to the Babcock & Wilcox Co. Fluor Corp. has been selected as the construction contractor. The reactor will be operated by the Phillips Petroleum Co., the present operator of the MTR and ETR for the Commission.

Programs are presently underway at Oak Ridge National Laboratory for development of the ATR fuel elements, and at Babcock & Wilcox to confirm the reactor core physics with a critical experiment.

High Flux Isotope Reactor (HFIR)

The High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory is being built primarly for the production of transplutonium radioisotopes, but it also will be used to study the effects of fast flux radiation on the properties of various materials. The HFIR will have a normal operating power level of 100 thermal megawatts, and will provide a maximum thermal flux of 5.5×10^{14}, which is greater than any other reactor.

Construction of the HFIR began at Oak Ridge in July with H. K. Ferguson Co. as the construction contractor. It is scheduled for operation early in 1964.

Nuclear Fuels and Materials Development

In addition to work on specific individual power and military reactors, the Commission conducts a broad-based development effort on fuels and materials under its nuclear technology program. Work in this program is carried out at the national laboratories and in private industrial and research institutions under contract to the Commission.

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In 1961, this effort was expanded somewhat to include additional work on advanced high temperature materials research.

High Temperature Materials

Subsequent to the termination of the Aircraft Nuclear Propulsion program in March, a technical team from the Commission reviewed research in progress at the General Electric Co., Evendale, Ohio; at Pratt & Whitney Aircraft Division of United Aircraft Corp. at the Connecticut Aircraft Nuclear Engine Laboratory, Middletown, Conn.; and at Oak Ridge National Laboratory with the intent of utilizing uniquely competent manpower, facilities, and equipment on advanced high temperature materials research. Evolving from this review, a research and development program on nuclear materials, directed toward their use at temperatures in excess of 2,000° F., has been undertaken at these organizations.

Areas of research include basic engineering investigations on ceramic and metallic nuclear fuel, development of protective coatings for use in high temperature corrosive environments, containment of molten metals at elevated temperatures, and studies of the effects of radiation on properties of metals and alloys at high temperatures. Such research is of prime importance to the success of advanced civilian, military, and space reactors.

Fuels Development

Gas pressure bonding. A fuel element fabrication process involving high temperatures and pressures for extended periods of time has been developed at Battelle Memorial Institute (BMI) to a point where commercial fuel element fabricators are now installing gas pressure bonding equipment. Both the Martin Co. and Westinghouse have recognized the advantages of this unique fabrication technique and are currently installing the necessary equipment. Efforts at BMI on gas pressure bonding are now being rescoped to examine potentially promising modifications of the process as it exists today.

Coated particles. Research on coated particle fuels is currently receiving major emphasis through closely coordinated effort involving the civilian gas cooled reactor program, and more recently the civilian boiling water reactor program. The many potential benefits of coated particle fuels such as assuring a uniform dispersion of fuel in matrix, preventing chemical reactions between fuel and matrix, fuel and cladding material, and retention of fission products has caused active interest throughout the reactor industry. This pro-

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gram involves development of impermeable coating of aluminum oxide and beryllium oxide on uranium oxide; coating of spherical uranium carbide with pyrolytic graphite; development of voids and porous layers within coated particles to accommodate fission gas, and the irradiation and evaluation of selected coated particles.

Extruded UO_2. Allis-Chalmers, under a subcontract to the Ford Motor Co., has succeeded in producing a straight, high density extrusion of UO_2 six inches in length. Under a Euratom contract with the same objective, CICAF [4] of France has also reported success. Both organizations have been invited by the Commission to submit comparable specimens to the General Electric Co., San Jose, Calif., for irradiation under the GE fuel cycle program. This full-scale bundle irradiation will provide valuable information on the performance of extruded UO_2. The information, combined with economic considerations, should allow an evaluation of this material as it pertains to future civilian reactor applications.

Irradiation of fuels. General Electric has begun irradiation of special fuels under the Commission's Fuel Cycle Development Program. This program has the objective of extending fuel life information on oxide fuel for boiling water reactor service to high specific power operation (20 kilowatts per kilogram) with irradiation lifetime targets of 15,000 megawatt days per ton (MWD/T). Approximately 50 assemblies are being irradiated. They consist primarily of stainless steel or zircaloy-2 rods containing UO_2 pellets. A special feature of the irradiation program is the evaluation of a number of fuel assemblies representative of recent developments in reactor fuels.

Uranium carbides. Investigations involving the uranium carbon system during the past year have brought into focus certain of the problems surrounding this new reactor fuel. High burnups have been attained with little or no apparent damage to the bulk fuel. However, the compatability of this material with various cladding materials is now recognized as an area requiring extensive investigation. Carbon diffusion becomes a significant problem when dealing with a hyperstoichiometric (with respect to carbon content) uranium carbide; on the other hand, if hypostoichiometric uranium carbide is used, free uranium may form at the grain boundaries. The free uranium could react with cladding material to form a eutectic which would reduce the melting point of the cladding. An exact stoichiometric composition is difficult to obtain and its behavior is still uncertain.

[4] Compagnie Industrielle des Combustibles Atomiques Frittes.

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An extensive program recently has been initiated of alloying ...nium carbide as a means of improving the stability of the system ...well as enhancing the elevated temperature properties.

...ium-uranium metal. The Argonne National Laboratory (ANL) ... found that solid solutions of ThO_2–UO_2 have good dimensional ...ility and corrosion resistance in NaK under irradiation to burn-... ranging from 17,600 to 22,900 MWD/T. ANL has found that ...ium-uranium metal alloys up to, and including, 20 weight percent ...nium exhibited excellent dimensional stability during irradiation. ... rate of volume change increased with increasing uranium con-... but the maximum rate at 700° C. was much less than for any ...wn uranium base alloy. These ceramic and metallic fuels will be ...licable to commercial power reactors in which it is desired to pro-... uranium 233 for additional fuel loadings.

...illium oxide. Although beryllium oxide (BeO) has been pro-...d for use in numerous reactor systems, the irradiation character-... and performance of this material remain unknown. With this ... basis for investigation, an extensive irradiation program has been ...ated at the Nuclear Materials and Propulsion Operation of the ...eral Electric Co. Various parameters, including density, purity, ...sity, grain size, and temperature will be evaluated as they pertain ...e stability of this material in the neutron environment. Infor-...on from this program is of immediate value to the Maritime Gas ...ed Reactor project.

...sic irradiation damage mechanisms in BeO are being investigated ...ak Ridge National Laboratory, whereas the recently rescoped ...TO BeO effort at Atomics International will provide the neces-... out-of-pile physical and mechanical property data on beryllium ...e.

...rials Development

...actically all reactor concepts are concerned with the effects of ...iation on structural materials presently being used in nuclear ...tors.

...irradiation. Battelle Memorial Institute and General Electric ...ford) are conducting studies to provide data on the change in ...nical properties during in-pile irradiation. Brookhaven and ...Ridge National Laboratories are performing fundamental studies ...ermine the damage mechanisms induced in structural materials. ...Naval Research Laboratory (NRL) is conducting post-irradiation ... of structural materials to determine the change in mechanical

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properties such as tensile strength, ultimate strength, elongation, and brittle-ductile transition temperature.

Battelle has recently examined material taken from the Engineering Test Reactor which was subjected to about 2.5 to 7.5 x 10^{21} neutrons per square centimeter. The results show that greater changes in properties have occurred as a result of irradiation at 750° F. than at 120° F. The degree of embrittlement in those irradiated at 750° F. indicates an approaching serious condition.

It is intended to expand the effort in this field to include additional in-pile tests on specimens under multiaxial stresses and fatigue. The effort at NRL will be expanded to obtain information on irradiation effects on low alloy and carbon steels at elevated temperatures and the results of irradiating material, annealing the material, and then re-irradiating. Another effort at NRL will be concerned with attempting to determine the effects of irradiation on allowable operating stress of structural components of pressurized water and gas cooled reactors.

Control rods. The General Electric Co. has completed a definitive study of control rods for water reactors. The study included a comprehensive analysis of reactor physics of control materials, optimum fabrication techniques for control materials, and stability of said materials in boiling water. As a result of the program, a prototype control rod consisting of co-deposited tetra boron carbide and nickel has been inserted in the Vallecitos Boiling Water Reactor for long term irradiation. This rod will be given detailed hot cell examination following exposure.

Thorium Utilization Program

In view of the vast quantity of energy latent in thorium ore reserves, and the favorable characteristics of thorium-232 for regenerating fissionable material in power reactors which operate primarily on neutrons of thermal and intermediate energy, a program has been instituted to develop the general technology for thorium fuels and to make possible the economic utilization of thorium in power reactors. The objective of the thorium utilization program is to develop the technology necessary for exploiting the favorable characteristics of thorium fuels and for handling the unfavorable ones in such a way as to produce low cost fuel cycles and economically competitive power reactor systems. Thorium fuel has a number of unfavorable features or problems which need to be investigated.

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Early work in the program will include development of recycle techniques for thorium fuel returned from existing or planned reactors such as the Elk River Reactor, the Consolidated Edison Thorium Reactor, and the High Temperature Gas Cooled Reactor.

Although a number of contractors working on various aspects of the fuel cycle will be involved in the program, the major effort will be centered at Oak Ridge National Laboratory (ORNL). The present effort at ORNL involves evaluation and physics studies of promising thorium reactor concepts, including breeders, investigation and development of slurry and pellet fuels, metallurgy work, and development of reprocessing and fabrication techniques. The first technique for fuel refabrication under development at ORNL is the sol-gel method of making mixed thorium oxide-uranium oxide, combined with the vibratory compaction method for loading zircaloy or stainless steel tubes.

Direct Conversion

The program for direct conversion of heat to electrical energy consists of efforts in both the thermoelectric and the thermionic[5] fields. Radioisotopes are used as the heat source for the various SNAP thermoelectric devices now being produced, such as SNAP–7A, B, C, and D, for Coast Guard and Navy use, and the SNAP devices now in use in the TRANSIT Navigational satellites. The thermoelectric material used in the SNAP–7 series is lead telluride, and the heat source is strontium 90. The SNAP–10A, is being developed for space use and is a reactor-heated thermoelectric system intended to produce about 500 watts.

In addition to the devices actually being produced, a research effort is being supported which has as its objective the development of a high power, thermionic system for space or terrestial use.

This program includes the work at Los Alamos Scientific Laboratory on the so-called plasma thermocouple, a thermionic cesium diode which uses bare UC–ZrC as both fuel element and emitter. In-pile tests are being conducted on these cells, and temperatures of about [illegible] C. are used as emitter temperatures. Lifetimes of several hundred hours have been achieved at reasonable power outputs and efficiencies. This work will continue.

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[5] Thermoelectric devices make use of the *Seebeck* effect to convert heat to electrical energy, i.e., one junction of two dissimilar conductors is heated, while the other junction is cooled causing a current to flow in the circuit. Thermionic devices make use of the Edison effect, i.e., when a metal is heated, electrons are emitted which may be collected by a cool electrode and which then pass through an external circuit back to the emitter, producing electrical energy.

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Other work on cesium thermionic diodes is being supported at Atomics International under the SNAP program, and at The Martin-Marietta Corp. on isotope devices. A program is also being conducted at Martin to develop thermoelectric materials which will operate efficiently at temperatures higher than presently employed materials can withstand. Selected metallic silicides are being prepared and tested with the objective of developing these materials for use in space applications where the higher operating temperature range is particularly attractive.

During 1961, the Commission consolidated administrative responsibility for direct conversion work other than specific SNAP programs in one branch. It is now planned to augment the above effort with additional programs with the objective of advancing the state-of-the-art in direct conversion systems so as to achieve an ultimate capability for the high power nuclear system. It is expected that work in low temperature (about 1,300° C.) cesium diodes will be supported with a view towards achieving an early capability for a practical thermionic reactor system. Also, work at Martin on diodes using elements other than cesium for an ion source is planned. A high temperature program (2,000° C.) is being planned which will include in-pile tests to augment the Los Alamos work.

Reactor Engineering and Component Development

High Temperature Work

The feasibility of sustained operation of a reactor system at severe conditions was demonstrated late in 1960, when the Induction Simulated Reactor (ISR) facility, operated at Morgantown, W. Va., as a joint Commission-Bureau of Mines project, successfully completed a test of 1,000 hours of continuous operation at rated conditions of 2,500° F. gas temperature and 250 psi pressure.

After shutdown and disassembly, an examination was made early in 1961 which revealed no damage to the components. The condition of the graphite spheres heated by induction indicated that only small amounts of graphite reacted with contaminants in the recycled helium. The ISR was then reassembled and tests on heat transfer were resumed.

During the year, life testing of heat exchanger tube materials was completed, and this facility was used to determine heat transfer coefficients for high temperature helium heat exchangers under a variety of flow conditions. Also, an endothermic chemical process heat exchanger has been designed to demonstrate the gasification of coal. This heat exchanger is under construction and will be incorporated

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the ISR during the first half of 1962. It will use heat from the recycled-helium simulated reactor coolant to promote the chemical reaction of coal and steam to produce gas. It is expected that the ISR will provide sufficient heat to react approximately 10 pounds of coal per hour in a continuous process. An interesting feature of the work during 1961 was demonstration of the ability of this system to generate steam at high pressures and temperatures up to 1,800° F.

During 1961, a comprehensive study was completed of the design criteria and operational requirements for mechanical components (compressors and turbines, circulators, bearings and seals, heat exchangers, pressure vessels and supports, valves and piping) for use in high temperature gas cooled reactor systems.

Instrumentation and Control

Development has been completed at Oak Ridge National Laboratory (ORNL) of a new, wide-range instrument for reactor control use. This instrument will measure and indicate reactor power level and period over the entire operating range of the reactor without any switching or change of instruments or ranges. The unique feature of this instrument system is a servo-controlled neutron flux sensor which is automatically positioned to maintain a pre-determined counting rate. This development will provide a single instrument to replace at least two of those now necessary. It fulfills a need in reactor control to eliminate possible "blind spots" and the necessity for switching instruments as a reactor is started up and brought to full power.

Another development at ORNL is the demonstration of improved scram-rod release devices for reactor protective systems. Through the use of three separately energized multiple-coil magnet windings (any two of which are capable of supporting the scram rod) and two-out-of-three coincidence circuitry, high system reliability has been obtained. Previously, two-out-of-three coincidence techniques have been applied widely in protective systems only in portions of the protective channels ahead of the rod release mechanism. The principle of the new development can be applied to any coincidence circuit arrangement. Two-out-of-three coincidence techniques are employed wherever a protective system is required to scram a reactor upon receipt of coincident scram signals in any two scram channels. In this way, false scrams resulting from extraneous noise or malfunction in one channel are minimized. In addition, when a two-out-of-three coincidence system is employed, one channel can be deactivated for maintenance and testing while the remaining two channels continue to guard the reactor.

A new instrument development for measuring neutron flux levels inside a reactor core uses the principle of activation of argon gas in "sensing cells" situated in the core. In this technique, the gas passes continuously through capillary tubing to the sensing cell, then to an ionization chamber outside the reactor shield. This instrument is expected to find application in high temperature reactors, particularly since it eliminates the need for gas tight seals, high temperature electric signal cable, gamma compensation, and the periodic replacement of fission chambers.

Remote Control Equipment

Argonne National Laboratory has been the leader in development of remote handling manipulators incorporating a sense of feel or touch for the human operator. In past years, manipulators incorporating this principle of feedback have been developed, first in a mechanically operated model capable of lifting 25 pounds, then in an electrically operated model with capacity of 50 pounds. Argonne has now developed a hydraulically operated manipulator incorporating force-reflection which is capable of handling 100 pounds at the remote fingers.

Chemical Processing Development

Chemical processing involves the conversion of irradiated nuclear reactor fuel elements into products suitable for refabrication into fuel, products returnable to the Commission for credit, and waste products which can be stored safely. Chemical processing is considered justified whenever material can be recovered for a credit greater than the cost of processing. The three general approaches being followed in Commission work are (*1*) aqueous processing with single or multiple dissolution facilities; (*2*) uranium hexafluoride volatility processes; and (*3*) integrated low decontamination processes in which a reactor and processing plant are built and operated as a single unit.

Aqueous Processing

Aqueous processes are the most advanced in development as a result of many years of experience gained in uranium and plutonium production programs. The aqueous nitrate solvent extraction system has proved very effective in actual plant operations. As a result, effort has been directed to the development of technology to allow for ultimate conversion of the widely diversified variety of civilian power reactor fuels to a nitrate system for the subsequent standard solvent extraction.

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During 1961, the scope and objectives of the aqueous development program were reappraised, as were the specific functions of the Oak Ridge National Laboratory (ORNL) and the Idaho Chemical Processing Plant (ICPP). As a result, ORNL was established as the site where cold engineering-scale research and development are conducted, and the ICPP was designated as the site where hot pilot plant demonstration operations when warranted, would be conducted. These sites, working together as a team, will develop the required technology from conception through practical demonstration. Existing facilities at both sites will be utilized to the maximum extent.

Several approaches to the handling of the wide diversity of reactor fuels under development are being pursued. During 1961, significant progress was made.

Chop-leach techniques. For several years a mechanical device has been under development to chop metallic-clad UO_2 fuel elements into segments, thus making possible direct dissolution of UO_2 in nitric acid. The advantages of such a system include its potential universality for UO_2 fuels clad in a variety of metals, and the ready adaptability to standard solvent extraction technology. During 1961, an engineering scale chop-leach unit was completed and satisfactorily operated at ORNL with cold prototype UO_2 fuel elements. This technology will be demonstrated in the ICPP hot pilot plant with highly irradiated fuel elements.

Dejacketing of sodium bonded metallic fuel. A mechanical device for dejacketing and removal of sodium bonding from metallic uranium fuel was successfully operated in 1961. The entire first irradiated fuel from the Sodium Reactor Experiment was dejacketed in this unit. The technology developed will be of value for possible application to the handling of other similar reactor fuels.

Titanium dissolver system. Technology was developed to the point where it was found desirable to design a titanium dissolver system for installation in the ICPP hot pilot plant. This system, when completed, will allow process demonstration on a full radioactive scale of the nitric acid-hydrochloric acid (Darex) process for stainless steel type fuels. This system also holds promise for application to the processing of advanced ceramic type fuels which might require dissolution by gas-solid reactions with subsequent feed adjustment in titanium processing equipment.

Electrolytic dissolution. Application of electrolytic techniques to the dissolution of metallic fuels in nitric acid has been under development. Promising results have been obtained. Major problems which

require resolution include maintenance of electrical contact with the dissolving fuel, elimination of arcing, the handling of sludges, and the selection of adequate materials of construction.

Volatility Processing

Fluoride volatility separation processes are based on the conversion of uranium and plutonium in reactor fuels to compounds which are separable from the fission products, and other fuel constituents, by virtue of their differences in volatility and chemical stability. Volatility processes for reactor fuel repurification depend upon three principal operations: (*1*) conversion of the fuel into a form suitable for reaction with fluorine gas or other fluorinating agent; (*2*) fluorination of the prepared fuel accompanied by separation of uranium and plutonium from the bulk constituents of the fuel and from most of the fission products; and (*3*) final separation of uranium, plutonium, and the more volatile fission products. Volatility techniques are also applicable to the reprocessing of highly enriched reactor fuels for which the separation and recovery of plutonium is not required. Volatility processes are being studied as the only known high-decontamination alternative to aqueous methods. They also offer potential economic advantages relative to aqueous methods due to a reduced number of process steps and reduced volumes of high level wastes which are produced.

Significant progress was made in the development of volatility technology in 1961. Use of inert fluid beds as media in which to conduct the highly exothermic gas-solid volatility reactions for a variety of fuels was established as technically feasible. Additional data were developed on the formation and handling of plutonium hexafluoride, an extremely difficult problem due to the tendency of this compound to be reduced to the solid plutonium tetrafluoride. Laboratory development during the year led to the successful formation and handling of multigram quantities of plutonium hexafluoride. Other areas which require additional research and development are engineering design and scaleup, and materials of construction and corrosion, as well as broadening the range of applicability of volatility methods.

Low Decontamination Processes

In low decontamination processes—also called pyrometallurgical and closed-cycle processes—all operations in the fuel cycle from decontamination through re-enrichment and refabrication are performed by remote control in a facility closely integrated with a specific reactor. This approach recognizes that the customary high decontamination of

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radiated fuels, associated with manual refabrication of fuel elements, may not be required by high burnup civilian power reactors. The closed-cycle fuel concept presents technical difficulties. Unless reasonable economies can be shown, its greatest application will be to reactors with large fuel inventories such as fast reactors, or to those that operate on plutonium recycle or thorium-uranium 233 fuel systems which may require remote refabrication.

Pyroprocessing demonstration of nonmetallic fuel samples was continued at Atomics International under Commission contract. A stainless steel clad uranium dioxide fuel sample, irradiated to 15,000 megawatt days per metric ton of uranium, was remotely declad and reprocessed through successive oxidation-reduction cycles. After remote refabrication, it will be reinserted in a reactor for further irradiation. Additional cycles of remote reprocessing, refabrication, and re-irradiation are planned to allow evaluation of this potential power reactor fuel cycle.

A pyrometallurgical reprocessing facility, integrated with the Experimental Breeder Reactor No. 2, is nearing completion at the National Reactor Testing Station. This facility was designed to reprocess and refabricate remotely the fuel from the core of the reactor, and to demonstrate a process for the blanket material.

A major advance was made at Argonne National Laboratory in the development of advanced technology for the recovery of uranium and plutonium from waste residuals produced in the core reprocessing operation. The technique also holds promise as a desirable method for the reclamation of plutonium bred in the blanket.

Environmental and Sanitary Engineering

One of the more perplexing problems associated with the use of nuclear energy is the disposal of the unwanted byproducts that range from only slightly hazardous, such as laboratory or fuel element fabrication debris, to highly hazardous liquid wastes created when spent fuels from reactors are chemically reprocessed. The Commission has long recognized that management of these radioactive wastes is an important factor in the health and safety program of the nuclear industry. Accordingly, the Commission has pursued a vigorous program aimed at developing methods and techniques for minimizing the release of radioactive contaminants to the environment.[6]

[6] This section contains only a summary of the Commission's activities in the radioactive waste management area; a more detailed description of the program is included in the Commission's special supplemental report "Atomic Energy Research—Life and Physical Sciences. Reactor Development and Waste Management, December 1961," available from Superintendent of Documents, Government Printing Office, Washington 25, D.C.

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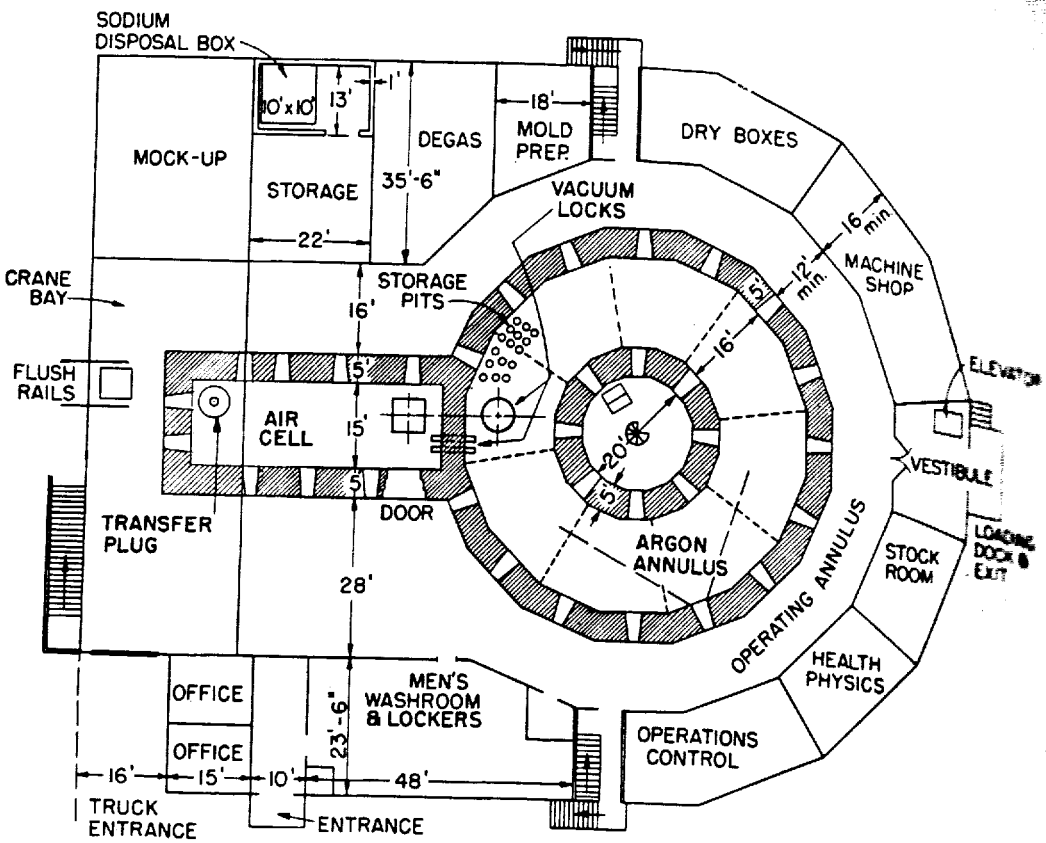
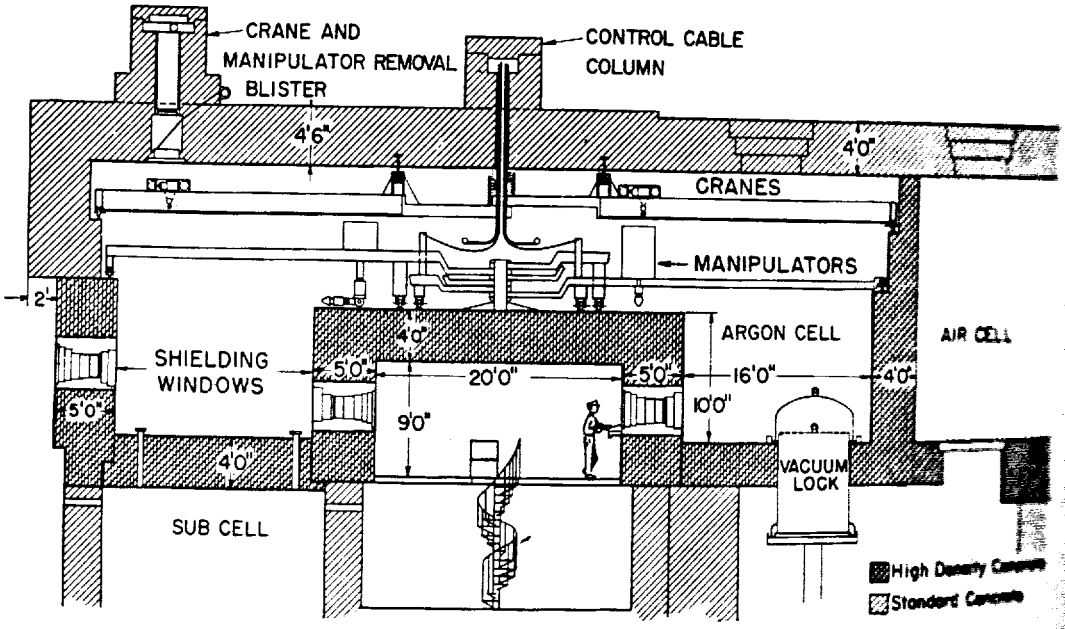


Processing Building. The Experimental Breeder Reactor No. 2 in Idaho will have an integrated fuel reprocessing system. The *upper diagram* shows the main floor layout of the processing building where still-usable plutonium and uranium will be extracted from the spent fuel elements and refabricated into new fuel for the reactor. All operations on purification of the fuel and refabrication will be carried on by remote control (within shaded areas of diagram). The *lower diagram* shows a sectional view of the "argon cell", in which a high-purity inert atmosphere will permit work with pyrophoric materials in the reprocessing work.



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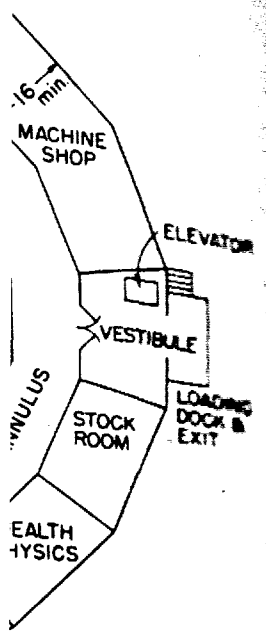

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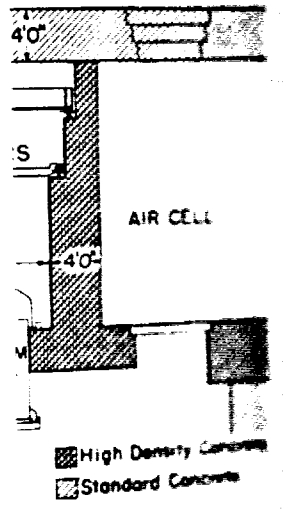

Environmental Studies on Waste

Cooperative studies are being conducted at national laboratories and at other Federal and private institutions on specific ground, air, and water environments which may receive limited discharges of low-activity and intermediate-activity radioactive wastes from nuclear power fuel fabrication, reprocessing operations, and research. The waste disposal problem of each such operation is evaluated on an individual basis to fit varying site characteristics and inherent differences in the waste characteristics.

A comprehensive study initiated in 1960 of the Clinch River, downstream from Oak Ridge, Tenn., is being carried out with the guidance of the "Clinch River Study Steering Committee." This committee includes representatives of the Commission, the Oak Ridge National Laboratory (ORNL), the U.S. Public Health Service, the U.S. Geological Survey, the Tennessee Valley Authority, the Tennessee Fish and Game Commission, the Tennessee State Health Department, and the Tennessee Stream Pollution Control Board. The purpose of the study is to obtain fundamental information on the physical, chemical, and biological dynamics of a flowing fresh-water ecologic system which is receiving low-activity radioactive wastes in order to predict the ultimate fate of radionuclides released to the system and recommended modification to waste management. In addition, routine monitoring and sampling in the Clinch River are conducted by ORNL to assure that concentrations of radioactive material are well within guide levels for drinking water.

Laboratory groups from ORNL have conducted annual surveys of both the Clinch and the Tennessee Rivers to analyze reconcentrating phenomena in stream sediments. In the Clinch River, measurements were made at 50-foot intervals across the width of the river every two miles. Ten measurements, ten miles apart, were taken along the Tennessee River. It is estimated that from 1943 to 1960 the radioactivity deposited in the Clinch River between mile 20.8 near Oak Ridge and the river's mouth totaled approximately 1,670 curies. Since the radioactivity is dispersed over the bottom area of the Clinch River is not considered to present a hazard.

The Public Health Service is carrying out stream studies at other Commission sites. Reports are now being completed on studies of the Mohawk River near Knolls Atomic Power Laboratory (KAPL), N.Y.; the Ohio River near the site of the Shippingport Atomic Power Station; and at Lower Three Runs Creek at the Savannah River Plant, S.C. At KAPL and Shippingport, results indicate the concentrations of radioactive waste materials being discharged are so low that quantitative isotopic measurements on the fate of these materials cannot be obtained. Preliminary results from Lower Three Runs

Creek indicate that all levels of radioactivity are well below recommended concentration guide levels.

A joint project is being conducted by the California Institute of Technology and Scripps Institute of Oceanography on studies of the origin, effects, and fate of radioactivity introduced into a municipal sewerage system. Tracer amounts of beta emitters, such as strontium 90 and other isotopes, are being studied in about ten sewage treatment plants around the United States, including the Los Angeles plant, to determine the behavior of the materials in sewage treatment plants and also to help evaluate the effectiveness of the Commission's waste-release criteria for licensed operations.

Sea Disposal

Studies of actual conditions at Pacific Ocean sites where wastes are dispersed are being conducted by Scripps and, more recently, by the Advanced Systems Development Division of Pneumodynamics Corp. Samples of water, various biological forms, and bottom sediments are collected and analyzed for radioactivity. None of the samples showed radioactivity attributable to waste disposal operations.

The Chesapeake Bay Institute of The Johns Hopkins University and the U.S. Coast and Geodetic Survey have been cooperating in a joint study designed to develop a complete mathematical understanding of the New York harbor system from West Point, N.Y., to the mouth of the harbor, including the East River. The work involves analysis and interpretation of tide, current, temperature, and salinity data collected and collated by the Coast and Geodetic Survey. This data was programmed for a computer to formulate a mathematical model which will enable anyone to predict the dispersion of any contaminant introduced at any point in the harbor system.

The Commission engaged in an evaluation of all types of containers currently used in sea disposal operations during the past year. One phase of this study involved the testing at sea of about 150 actual disposal containers selected at random from waste packagers. The other phase involved a series of laboratory tests conducted by the Southwest Research Institute to measure the effects of pressure and impact forces on various types of containers. The data from these tests is now being used to develop recommendations for design and construction of sea disposal containers.

The Coast and Geodetic Survey has made a series of ocean current observations and has collected samples of sea water, bottom sediments, and biological specimens from three areas off the New England coast.

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objectives were to determine the suitability of the sites for pos- disposal of limited amounts of packaged radioactive wastes at future date, if necessary. Studies were made also of several sites used for disposal of packaged wastes. Measurements of activity of samples collected at the former Massachusetts Bay and two open ocean sites in the Atlantic at which packaged wastes been disposed showed essentially normal background levels of tion. There are no present plans to resume disposal of wastes in chusetts Bay or any of the other investigated areas off New land; the data and information thus accumulated will be useful, ever, for evaluating other sea areas.

-Level Wastes

t present the principal method of handling highly radioactive d fuel reprocessing wastes at the few sites where they are pro- d is to store them in special underground tank storage facilities appropriate monitoring. More than 15 years of experience have n that this method provides a safe, practical means of interim ge. Because of the long effective life (measured in hundreds of s) of these wastes, their great volume (estimated at about 65 on gallons total in 1959), and the comparatively short life— ated from 10 to 20 years—of the tanks containing the wastes, a tial hazard could conceivably result from using this method of ling over a long period of time.

recognition of this potential hazard the Commission is promoting rch and development along the lines of either transforming the s to solid form for long-term storage or disposal, or the possi- of placing the wastes, still in liquid form, in a geological en- ment which would serve as a safe, perpetual storage facility.

ation of high-level wastes in a solid form would not only de- the bulk volume of the wastes but would also make the radio- es relatively immobile, thereby facilitating management of the s and decreasing the hazard. Development work is being car- out in one area whereby the wastes would be fixed in solid form stored in an impervious environment, such as a salt mine, under nous monitoring.

d tests are still being conducted by ORNL on the technical ility of storing high-activity liquid wastes in cavities in rock- Recent developments in reactor fuel reprocessing indicate that ctivity waste volumes will be more concentrated, and could gen- heat at a greater rate than previously considered. As a result, wastes could not be stored in salt cavities with diameters greater

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than five feet without exceeding an acceptable temperature rise unless special cooling was provided. Other geometric configurations for possible storage are also being studied.

At the National Reactor Testing Station (NRTS), a 60-gallon-per-hour fluidized bed calciner, designed to demonstrate the feasibility of calcination to dry solids of aqueous aluminum nitrate wastes is undergoing initial tests. Full scale demonstrational studies are expected to commence in 1962. Laboratory studies are also being made to evaluate the applications of the fluidized bed technique to the handling of wastes from reprocessing of zirconium and stainless steel fuels.

Detailed design has been completed at Hanford for a pilot plant of the radiant heat spray calciner developed on a laboratory scale last year. Engineering cold tests and hot cell small-scale experiments will be conducted this year.

Cold laboratory and engineering scale studies are being carried out by ORNL on a pot calcination process for handling power reactor fuel reprocessing wastes. This work is being done in preparation for a hot pilot demonstration program on the pot and rotary ball kiln calciner which will be initiated at NRTS in 1962. Use of a rotary ball kiln for calcination of zirconium-alloy reprocessing wastes has been under study at Brookhaven National Laboratory with non-radioactive pilot plant tests being run during the past year.

Brookhaven also is working on a process in which the entire conversion from raw aqueous waste to final phosphate glass would be accomplished in an all-liquid system. Design and construction of a continuous process pilot plant is planned to demonstrate phosphate-glass fixation on a larger scale.

During the past year the Coors Porcelain Co. and the Los Alamos Scientific Laboratory (LASL) have jointly studied the fixation of liquid radioactive waste in ceramic sponges. A 10-gallon-per-day pilot plant will be installed at LASL during the coming year, which will operate with simulated waste to demonstrate the feasibility of this system.

The E. I. du Pont de Nemours Co., which operates the Commission's Savannah River Plant, has been investigating the practicability of storing long-cooled, semi-liquid fuel reprocessing wastes in underground caverns mined out of impermeable deep bedrock beneath the plant. In January, 1961, du Pont, in conjunction with the U.S. Army Corps of Engineers and the U.S. Geological Survey, initiated an exploratory drilling program in which approximately ten holes will be drilled. The first hole was completed to 1,900 feet, of which 1,000 feet were in bedrock.

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rmediate-activity Wastes

ome intermediate-activity wastes continue to be disposed into the nd at Hanford, Oak Ridge, and Savannah River. The inter-iate-activity wastes are those which, through natural decay, soon h a low-level radioactivity state. This operation is carefully con-led and monitored by the use of wells drilled around the perimeter the area. Monitoring instruments within the wells indicate any e seepage of the wastes through the ground strata. Concentra-s of radioisotopes appearing in surface waters are, as in previous s, still well below acceptable levels and present no hazardous itions. Research is continuing on the development of better ods for handling these wastes to eliminate the necessity of inject-them into the ground in aqueous form.

-activity Wastes

ow-activity liquid wastes are released to the environment either tly or after primary treatment. Research is being conducted ORNL, Hanford, and certain other installations on mineral and exchange methods for the removal of specific radioisotopes. Re-s of this research to date are encouraging.

addition, a joint program involving the U.S. Bureau of Mines, S. Geological Survey, ORNL, and the University of California derway investigating the feasibility of injecting low and inter-ate level wastes into deep geologic formations.

ne Effluent Studies

ring the past year, the Harvard Air Cleaning Laboratory has ued work on a small incinerator for burning low-activity com-ble radioactive wastes. The laboratory has developed an electro-precipitator capable of removing most of the tarry particulates, cause rapid plugging and deterioration of the filter surfaces. s centered around an inexpensive method of removing iodine reactor and chemical processing plant off-gas systems are also continued.

U.S. Weather Bureau is continuing meteorological research at Commission sites for the purpose of obtaining a better under-g of the ability of the lower atmosphere to disperse pollutants. problems have emerged during the past year: (*1*) prediction onuclide deposit as a function of weather and underlying land : (*2*) cumulative effects of more than one source of radio-as a function of space, time, and weather; and (*3*) variation spheric dispersion with geography.

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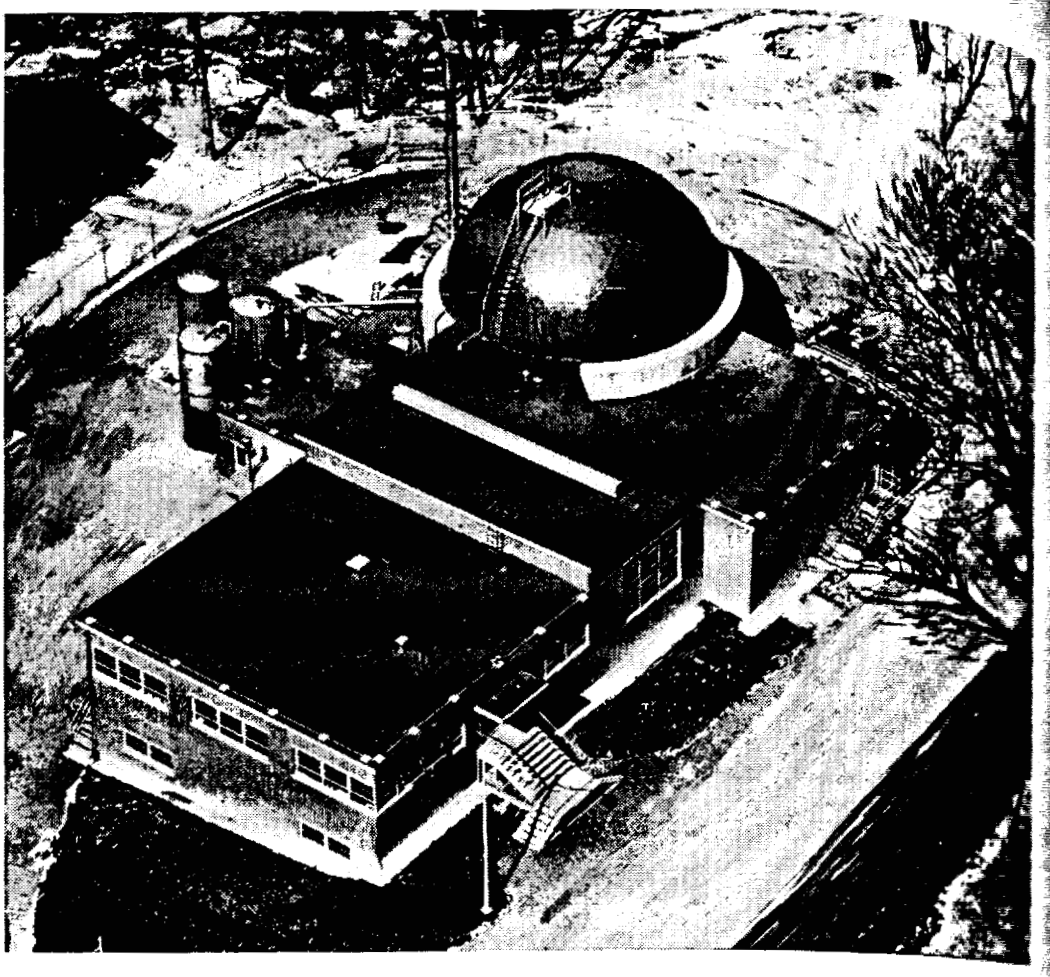

Oldest Army Reactor. After approximately 18 megawatt years of power had been produced from it, the first core of the Army's Stationary Medium Power Plant No. 1 (SM–1) reactor reached its end of life during April 1961. The SM-1, located at Fort Belvoir, Va., is the Army's oldest reactor project, having gone into operation on April 8, 1957. Originally known as the Army Package Power Reactor (APPR), the plant was built by Alco Products under Commission contract, and was turned over to the Department of Defense in 1960.

MILITARY AND RELATED REACTOR ACTIVITIES

During 1961, the Commission's program to develop reactor systems that will meet growing military needs was highlighted by:

- A pre-packaged, air-transportable reactor plant capable of producing 1,000 kilowatts of electricity was erected at Sundance, Wyo. It will demonstrate the feasibility of this type of reactor for use in remote locations.
- The first of two small reactor plants to be used in Antarctica for generation of electricity and space heating was shipped to McMurdo Sound and is being erected.

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• The U.S. Navy had 24 nuclear-powered submarines in operation, ght of them being of the Polaris missile type, and 24 others had been unched or were in an earlier stage of construction.

• The Navy's first two nuclear-powered surface ships, the aircraft rrier *Enterprise* and the guided missile cruiser *Long Beach*, were in operation.

• The Commission-Department of Defense program directed to-rd development of a nuclear propulsion system for manned aircraft s terminated.

• Tests with the Tory IIA–1 reactor in the PLUTO program, which directed toward development of a nuclear ramjet reactor for aero-namic missile applications, were conducted in May, September, and tober.

ARMY REACTORS PROGRAM

The objective of the Commission-Army reactor program is to de-lop a family of reactor systems that will meet the requirements of military services for nuclear power plants suitable for use in re-te areas or for unique military purposes. The reactor systems re-ving major emphasis are the pressurized water, boiling water, and -cooled systems.

Pressurized Water Reactors

tionary Medium Power Plant No. 1 (SM–1)

The *SM–1* pressurized water reactor at Fort Belvoir, Va., a 1,855 owatt (electrical) plant, continued to provide the Army program h a facility for training military operators, for developing plant rovements and for gaining operating data from a prototype nuclear wer plant. The basic missions and method of operation have not nged significantly since the transfer of the plant from the Com-sion to the Department of Defense (DOD) in 1960. The rear-ged and spiked Core I reached its end of life on April 15, 1961. ing 1960, the fuel elements had been rearranged and spikes of nium were inserted to extend further the core burnup. With this core, approximately 18 megawatt years of power were produced. II was inserted and achieved criticality on June 13, 1961. As of ember 31, 1961, this second core had produced 1,890 kilowatt years ower.

t the year's end, 78 military operators had completed one-year ning courses conducted in conjunction with plant operation.

The operators include personnel from the three military services who will operate the PM–2A in Greenland, the SM–1A in Alaska, the PM–1 at Sundance, Wyo., the PM–3A at McMurdo Sound, Antarctica, and the PL–3 at Byrd Station, Antarctica, as well as the SM–1 itself. Under an agreement with the Department of Defense, the Commission continues to use the facility for certain research and development work.

Stationary Medium Power Plant No. 1A (SM–1A)

Criticality of the *SM–1A* reactor will be achieved early in 1962, with operation at full power following shortly thereafter. Acceptance of the completed plant by the Army will take place after completion of contractor tests. The SM–1A, located at Fort Greely, Alaska, is essentially a direct extrapolation of the SM–1 design. It will have a higher power output, providing 1,640 kilowatts of electric power, and produce 46 million BTU's per hour of steam for space heating. (The SM–1 produces electrical energy only.) Construction of this DOD plant, which began in June 1958, had been delayed by steel shortages, local strikes, and intransit damage to plant equipment.

Stationary Medium Power Plant No. 2 (SM–2)

The *SM–2* core and pressure vessel program was brought to an orderly conclusion during 1961 after completion of component tests and reports. However, some work is continuing on the plant design of a 12,000 ekw complex, using the SM–2 features, to provide a substantially complete design for possible use in the future.

The SM–2 pressurized water project was initiated originally as a Commission effort to develop a 6,000 ekw core for use in a plant being designed for the Army by Alco Products, Inc. This plant was originally required to provide reliable high quality power for use at installations such as missile sites. During the plant design phase, the Nike-Zeus power requirements changed from 6,000 to 12,000 ekw. This increased power requirement was to be met by coupling two SM-2 6,000 ekw plants into a single complex capable of producing 12,000 ekw.

Portable Medium Power Plant No. 1 (PM–1)

The PM–1 is a 1,000 ekw pressurized water reactor which was developed under Commission contract with the Martin-Marietta Corp. and funded in part by the Air Force. The plant is modular in nature

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d was factory-assembled. It is the first plant to incorporate stain-
ss steel, uranium oxide, tubular fuel elements.

In mid-year, the packaged plant was flown by C–130 aircraft from
e factory in Baltimore to Ellsworth Air Force Base, Rapid City,
Dak. A total of 16 trips were required to move the major equip-
ent. The packages were then trucked to the plant site at Sundance,
Wyo., about 90 miles away. Site construction was complete at year's
d.

Because of the relatively short time required for erection and the
all number of air-transportable packages, the plant has proven
elf to be particularly adaptable for use at remote locations where
nstruction time and support facilities are limited. It is anticipated
at operation will commence in February 1962, with the plant being
rned over to the Air Force in September 1962.

rtable Medium Power Plant No. 2A (PM–2A)

The *PM–2A*, first of the pre-fabricated, packaged, air-transportable
ctor plants to be put into operation, continued to demonstrate the
lue of this type of plant. The PM–2A is located at Camp Century
Northern Greenland, about 150 miles east of Thule, and is a further
velopment based upon the SM–1 design. This Army-funded plant
s fabricated in 27 packages which were assembled and subjected to
-nuclear tests at Dunkirk, N.Y. The plant was then disassembled
d shipped by sea and air and overland sled to Camp Century. Ini-
l power operation was attained in November 1960, and after accept-
e by the Army in March 1961, the PM–2A became the first reactor
plying power and heat for a remote military post. The plant de-
n capacity is 1,500 ekw and 1 million BTU's per hour in the form
steam for melting heat for station water supply. During 1961 the
nt supplied 1,041,000 kilowatt hours of electrical power to the camp.

rtable Medium Power Plant No. 3A (PM–3A)

Fabrication of the 1,500 ekw *PM–3A* plant was completed in No-
ber 1961, and shipment to McMurdo Sound, Antarctica, was
pleted in December. Plant installation is now in progress. Dur-
1961, the site excavation, foundations, and building installation
e completed, and it is anticipated that initial operation will occur
March 1962. The scheduled date for the Commission to turn the
t over to the Navy is September 1962.

The PM–3A, which is essentially a contained version of the PM–1,
designed and constructed by The Martin Co. under a Commis-

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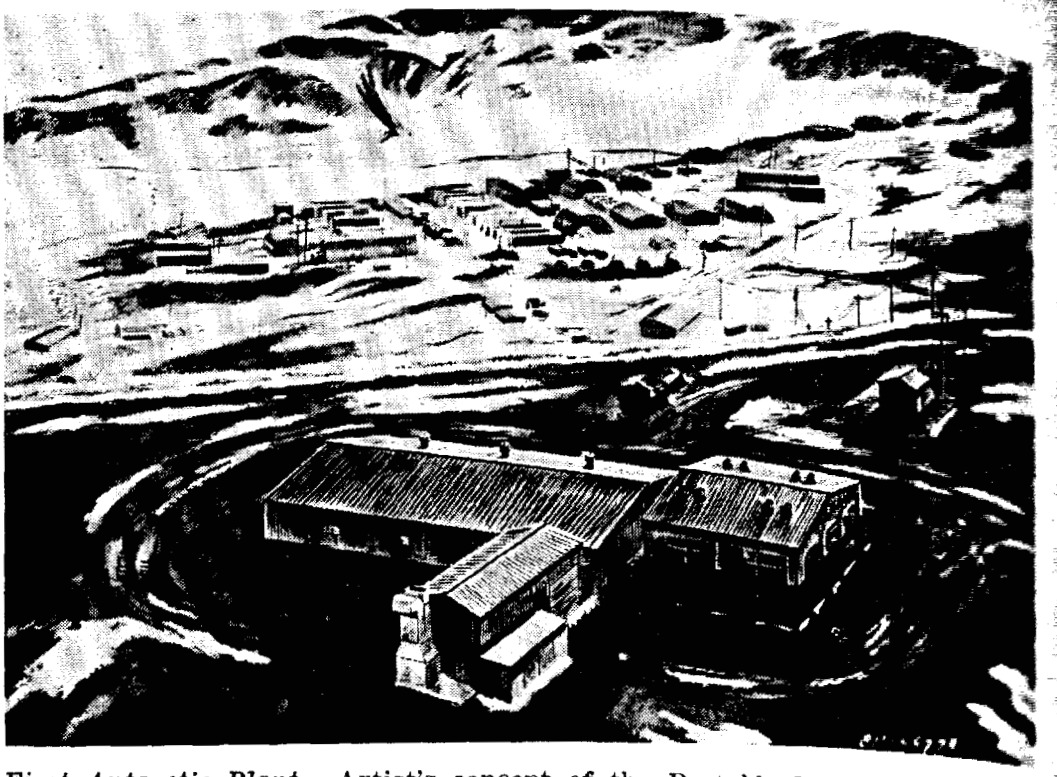

First Antarctic Plant. Artist's concept of the Portable Medium Power Plant No. 3 (PM–3A) now under construction at the Naval Air Facility, McMurdo Sound, Antarctica. The 1,500 electrical kilowatt pressurized water plant was fabricated by the Martin-Marietta Corp., under Commission contract. The plant was assembled, tested, and shipped to the Antarctic. When in operation, the plant will greatly reduce the logistical effort needed to supply fuels for the internal combustion engines now being used to furnish electricity to the principal base of U.S. scientific effort in the Antarctic.

sion contract funded by the Navy, for installation on land at McMurdo Sound. The fixed-price, guaranteed-performance contract used to procure this plant provides for liquidated damages in event of failure to deliver on schedule. It also provides for monetary damages if the plant fails to perform in accordance with certain requirements in the specifications.

Portable Low Power Plant No. 3 (PL–3)

The PL–3 plant is a new project, being conducted under a cost-plus-fixed-fee contract with Alco Products, Inc. The contract, which was awarded October 23, 1961, calls for concept selection, design, fabrication, pre-shipment test, field assembly, and test operation of a pressurized water or boiling water reactor plant, air-transportable in pre-packaged modules, to supply 1,000 ekw and 1.5 million BTU's of export steam at Byrd Station, Antarctica. Byrd Station is an ice tunnel installation operated by the Navy in support of National Science Foundation research programs. The site is about 800 air miles inland

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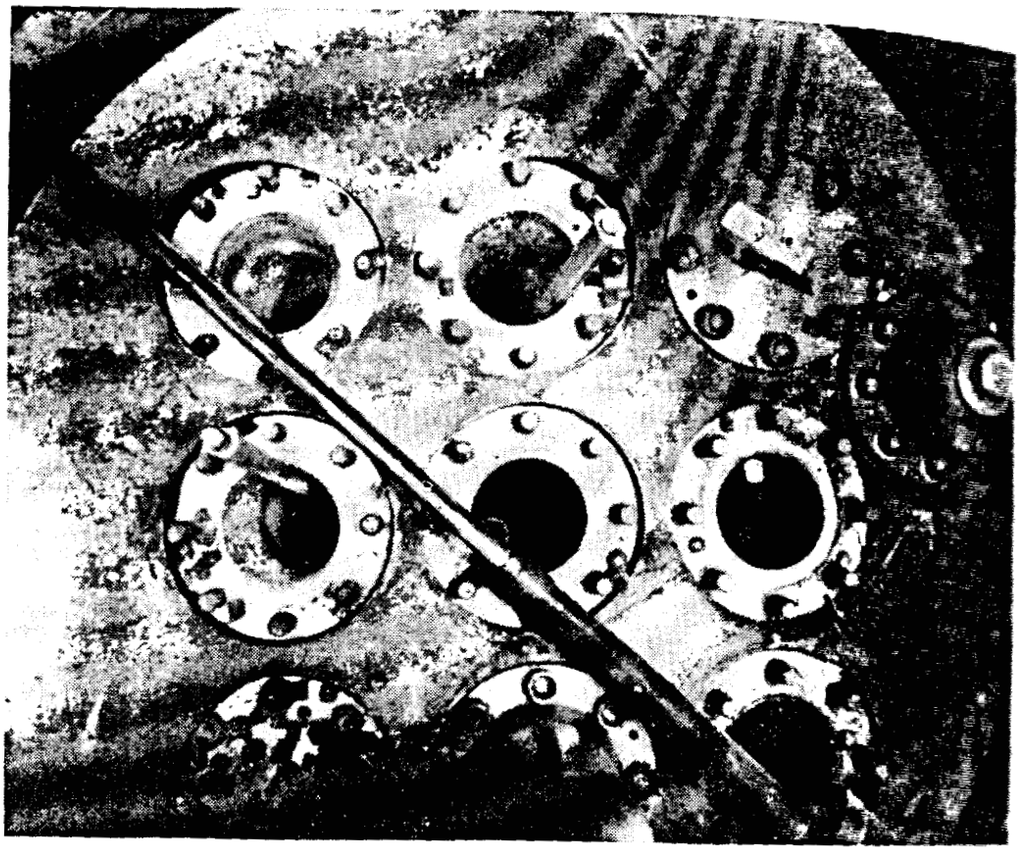
The reactor achieved criticality under guidance of the Argo National Laboratory staff on August 11, 1958, and attained full p on October 24 of that year. In February 1959 the plant was tur over to the Commission's contractor, Combustion Engineering. I for operation as an Army prototype facility.

After having been in operation on a regular basis for mor two years, the SL–1 was shutdown on December 23, 1960, for mai tenance. The reactor was scheduled to be started up again on Ja uary 4. It was during the evening of January 3, when the three technicians were engaged in pre-startup activities, that the nuclear excursion occurred.



Damaged Reactor. Efforts to determine the cause of the accident to the SL-1 reactor accident were hampered because examination of the damaged reactor could only be conducted by remote means since the radioactivity level adjacent to the reactor was too high for human tolerance. Above photo, a blow-up from a 16 mm movie film, was obtained by suspending a lead-shielded, motor-actuated camera from the boom of a "cherry picker" crane (see photo in Part 1 of this report). Photo shows that six of the nine nozzles in the reactor vessel top head are open to the atmosphere allowing radiation to escape from the core and that only one (upper left corner) is free of obstruction. Lying across the reactor top is a broken control rod extension shaft. In the nozzle openings, the other control rod shafts appear damaged or out of place.

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rimary efforts subsequent to the accident consisted of removal of ictims from the reactor building and determination of the status e reactor. Acquisition of data was greatly impeded by the re- ing radiation which, although tolerably low outside the reactor ding, continued at an extremely high level (initially, it was ap- imately 500–1,000 roentgens per hour) in the area immediately nd the reactor vessel. Because of this high radiation level within building, all efforts to determine the status of the reactor were cautiously and with remote handling equipment.

y April, Combustion Engineering had secured evidence that the tor would remain sub-critical provided no water or other mod- r was introduced into the pressure vessel. The General Electric was selected, with technical consultation to be provided by Com- ion Engineering, to perform the SL–1 decontamination and core oval.

neral Electric reduced the radiation level by various physical tamination methods, including the removal of equipment from reactor building. By the end of November, sufficient building ture was removed to permit lifting out the 13-ton pressure vessel the damaged core intact. The vessel was transported 40 miles low-bed truck to the disassembly building of the former Aircraft ear Propulsion site for dismantling and examination of the core. was done only after complete photographic examination of the in place. The primary objective in dismantling the core is to gain fullest possible understanding of what occurred. By the end of the the cause of the accident still had not been determined although gh knowledge had been gained to disprove some earlier otheses.

ortly after the accident the Commission requested surveys of ation and maintenance procedures of all AEC-owned or -licensed tors. The objective of the surveys was to obtain a comprehensive ure of certain aspects of reactor operations and safety procedures, ell as to assure that all needed safety precautions are taken dur- eriods of reactor maintenance.

e lesson that was learned from the accident was the need for better ation of contractor responsibilities for improving the manage- methods by which the Commission discharges its responsibilities safety of reactor operations.

ructions have been issued requiring increased emphasis on gh reviews of contractor hazard analysis of proposed facilities, difications thereto which have a bearing on safety. These re- will be made by technically qualified representatives of the Com- 's field Operations Office Managers. Instructions have been reemphasizing the importance of independent inspection of operations by Commission personnel.

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Operations offices have been directed to allocate, where necessary, increased personnel positions to provide for any additional technical staff required in their reactor inspection work and in reactor safety review procedures.

Statements of functions and delegations to Commission line officials in the Headquarters and Operations Offices have been revised to

Early Photo. Since the cause of the SL–1 accident was unknown and the radioactivity level too high for human examination of the reactor, investigators had to use photos such as these to determine the condition of the reactor. This photo, taken four days after the accident, showed that although the pressure vessel head was still in place, the reactor core was vented to the atmosphere by the two open nozzles on edge of reactor head nearest camera. Across the reactor head is a control rod extension shaft still fitted with its shield plug. On the floor in foreground are cylindrical steel punchings with some graphite and boric oxide which formed the dry-mixture shield above the reactor head. The investigation, conducted by remote photography, had to be done without dislodging anything that might fall into the reactor core through the opening and cause a second explosion.

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a. Prepare detaile
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Boiling Water Rea

Work continued
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phasize and clarify their safety responsibilities. Provision con-
es to be made for independent technical reactor hazards review of
posed reactor facilities and modifications to existing reactor facili-
by the staff of the Director of Regulation.

Although the scope of the Commission's standard health and safety
tract clause is sufficiently broad to cover the following matters,
itional contract provisions applying to those contractors having
onsibility for reactor operations are being provided for em-
s. These additional contract provisions explicitly require the
tractor among other matters, to:

Prepare detailed plans and procedures designed to assure the safe
peration and maintenance of the reactor.

Carry out a training program that will assure that the approved
lans and procedures for nuclear safety are completely understood
y all contractor personnel who will be engaged in the operation
nd maintenance of the nuclear reactor.

Assure that all operational and maintenance activities are per-
rmed by qualified and adequately trained personnel and, except
s otherwise agreed in writing, are conducted at all times under
he supervision of personnel who are able to appraise and control
mergency conditions that may give rise to the risk of a nuclear
cident.

Establish a system of inspection (including review of inspection
eports by a highly competent technical group) that will: (*1*) pro-
ide frequent and periodic checks of reactor performance and of
he qualifications and training of operating and maintenance per-
nnel; and (2) provide for investigation of any unusual or un-
redicted reactor conditions that might affect the safe operation of
he reactor.

Report promptly to the contracting officer any change in the physi-
al condition of the reactor or its operating characteristics that
ight affect the safe operation of the reactor.

The Commission has placed great emphasis on the safe operation
oth Commission and privately-owned reactors. The SL–1 acci-
t has underscored the importance of this policy. It is believed the
ective actions noted above will provide additional assurance that
quate competence and care are applied to the operation of all
tors.

ing Water Reactor Development

Work continued on the development of pre-assembled air-trans-
rable plants utilizing natural circulation boiling water reactors.
e plants are being designed to meet military requirements in the

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range of 300 to 1,000 ekw. Designs were completed on a 300 ekw plant for a sub-Arctic installation, and a 1,000 ekw contained plant for snow-tunnel installations. Studies were also completed on how these designs could be adapted to other applications. Fabrication development work was completed on a low-enriched core which will have an estimated core life of 30 thermal megawatt years. With this core, 300 ekw plants would be capable of operating about 10 years between refuelings, and 1,000 ekw plants would be capable of operating for three years at full power.

Cherenkov Glow. Photo shows the Gas Cooled Reactor Experiment (GCRE) operating at full power of two thermal megawatts at the Commission's National Reactor Testing Station in Idaho. The reactor, an experimental device in the development of a transportable Army reactor, is located in an 18-foot-deep pool of water. The light area around the reactor is the Cherenkov effect, a bluish-white glow caused when gamma radiation passes through water and other transparent substances. The glow arises when electrically charged particles travel through a medium with a velocity greater than that of light in that particular medium.

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Gas-Cooled Reactor

The *GCRE* facil
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Mobile Low Power R

The *ML-1* is a
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delivery has slipped
and performance tes
problems have arisen

Mobile Low Power R

The *ML-1A* will b
Army in the field.
ed for procuremen
capacity of 300 to

Gas-Cooled Reactors

Cooled Reactor Experiment (*GCRE*)

The *GCRE* facility at the National Reactor Testing Station had operating at full power (2 megawatts, thermal) until the SL–1 ent on January 3, following which the reactor was shut down for tended design and hazards review. In mid-February, the GCRE returned to power for endurance testing of a Mobile Low Power tor No. 1-type core. In April, the reactor was shut down to investe the failure of a pressure tube in the reactor pressure vessel. Cerother deficiencies in the fuel elements and control blades were dised during this investigation. Repair and modification programs initiated, and the facility was operated on a non-nuclear basis September to evaluate these repairs. The non-nuclear tests that there had been a general deterioration of tubes in the re vessel. The vessel was dismantled and sent to the hot cells mination. A replacement vessel will be installed by May 1962. purpose of the GCRE, which achieved criticality on Febru-, 1960, is to provide the facilities needed for the development testing of small, gas-cooled reactors. Operations have been aimed d developing engineering data and core testing in support of Mobile Low Power Reactor No. 1.

Mobile Low Power Reactor No. 1 (*ML–1*)

The *ML–1* is a prototype, mobile, gas-cooled plant with a net city of 300 to 500 ekw, which achieved criticality on March 30, at NRTS. The combined reactor and power conversion equipare designed to be transportable by standard military semitruck, railroad flatcar, barge, or aircraft. After criticality was ed, the reactor package was zero-power tested during the rest year. Delivery of the power conversion skid was scheduled for but, because of turbine-compressor lubrication problems, ery has slipped to March 1962, after which full power operation performance testing of the plant will be initiated. No significant ems have arisen during the initial testing of the reactor.

Mobile Low Power Reactor No. 1A (*ML–1A*)

ML–1A will be the first nuclear power plant for support of the in the field. This plant, based on the ML–1 design, is schedfor procurement by the Department of Defense. It will have city of 300 to 500 ekw and will be trailer mounted. Work

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ML–1 Core. Overhead view of the compact core and coolant vessel of the Mobile Low Power Reactor No. 1 (ML–1) being developed by the Commission for the Department of Defense. Photo shows the installation of a fuel element. The 300–500 electrical kilowatt, gas cooled reactor achieved criticality during March 1961. It is a prototype for a transportable reactor, and was developed from tech- nology obtained with the Gas Cooled Reactor Experiment (GCRE).

Portability Demonst transportable was d Mission's National shows the Commiss Army flatbed trailer. Force, by standard m

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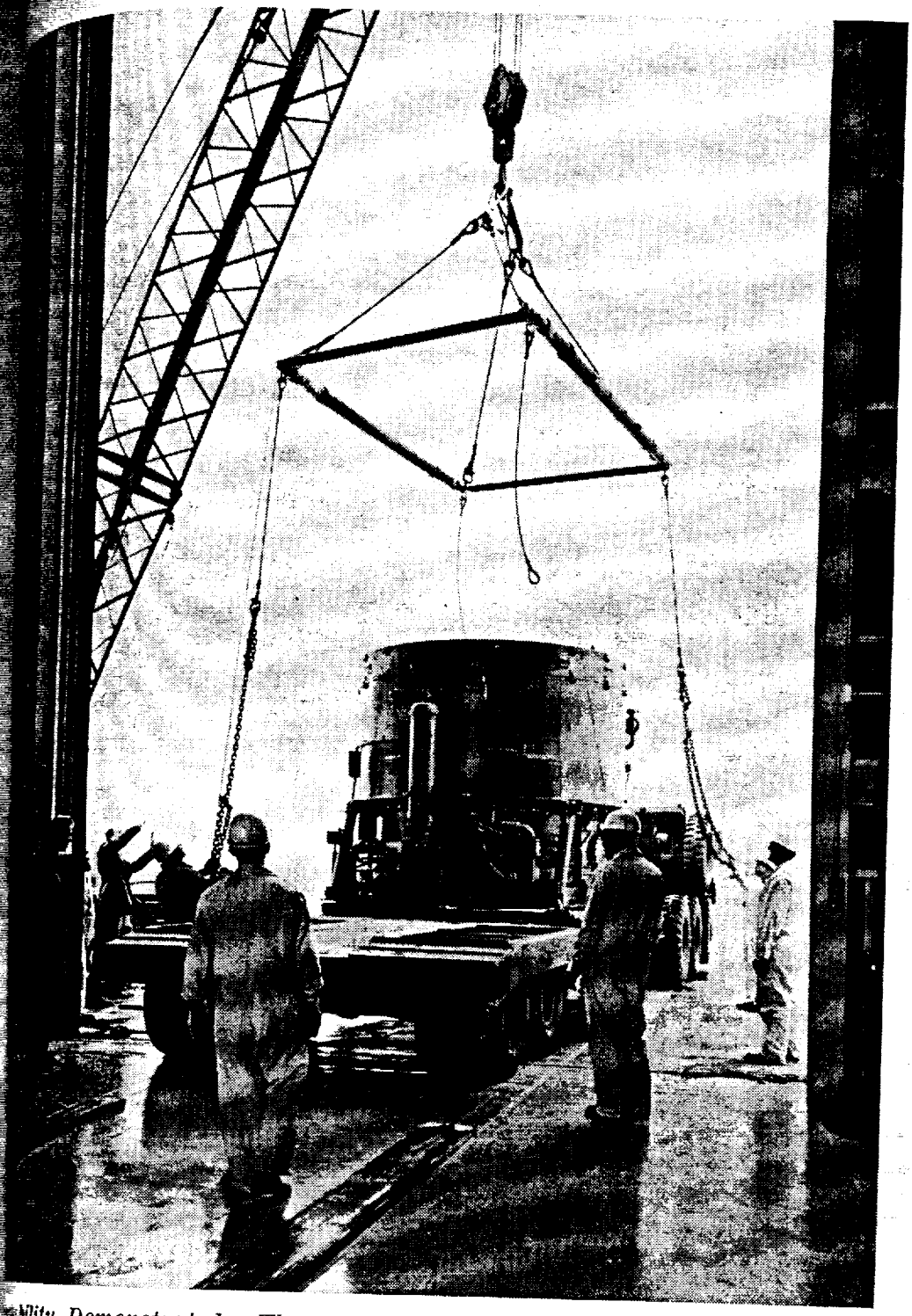

ability Demonstrated. That the ML-1 gas cooled reactor will be truly portable was demonstrated when the reactor package arrived at the Com- on's National Reactor Testing Station during February 1961. Photo the Commission-developed reactor arriving at its test site aboard an flatbed trailer. The reactor has been designed to be transportable, in one by standard military semi-trailer truck, railroad flatcar, barge, or aircraft.

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continued throughout the year on developing plans and specifications for incorporation into the ML–1A bid package. These plans and specifications are based on ML–1 design and performance.

NAVAL REACTORS PROGRAM

The objective of the Naval Reactors Program is the design and development of a group of naval nuclear propulsion plants in a wide range of power ratings for installation in ships ranging from small submarines to large aircraft carriers.

Prototype Plants

Six land-based prototype plants for specific naval shipboard applications and associated test facilities have been authorized for the development and test of various reactor plant systems, components, and reactor cores under the Naval Reactors Program of the Commission. Five of the prototypes are in operation and one is under construction.

S1W Reactor Facility

Early in 1961, the *S1W*'s operation commenced with a fourth core and continued during the year in the developmental and test program for fuel sub-assemblies in support of advanced core design work.

The S1W reactor facility, located at the National Reactor Testing Station, was initially designed and operated as the land-based prototype of the reactor plant installed in the *Nautilus*. The plant is now operated as a flexible test facility in support of more advanced development work on improved submarine reactor plant systems, components, and cores.

Submarine Advanced Reactor (S3G)

During the year, the *S3G* land-based prototype was used in a comprehensive test program conducted in support of advanced reactor plant development work. Operation with the initial core was completed, and a core of a new design was installed and placed in operation.

Located at West Milton, N.Y., the plant consists of a portion of a submarine hull containing one reactor, with its associated steam generating equipment and engine room machinery. A two-reactor propulsion plant of this type is installed in the large submarine *Triton* which, during 1960, circumnavigated the world while submerged.

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Small Submarine

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McMurdo Sound at an altitude of 5,000 feet and is completely ated, except for radio communication, about nine months of the . The contract with Alco Products calls for shipment of the plant the United States in September 1963.

urized Water Reactor Model and Code

The Martin-Marietta Corp. during 1961 made progress in the pro- to develop an integrated system of codes for small pressurized r-cooled and -moderated reactors to predict reactivity, rod posi- and power distribution as a function of core life for Army nu- power plants. Accomplishments in the theoretical area of the included completion and evaluation of three parts of the inte- d system of codes; the programming of a burnup code; and the in- ration of an improved neutron slowing-down model in the flux reactivity portions of the integrated code system. In support of integrated code program, experimental work included: the comple- of experiments on clean core critical assemblies, the development utilization of pulsed neutron techniques and homogeneous fuel ent substitution in these assemblies, and experiments on non- formly loaded assemblies.

The ultimate objective of the project is to provide methods to per- design of reactor cores with longer life, improved power distribu- reduced coolant flow and pressure requirements, and to refine ods of reactor control. Through the associated experimental ics program, the physical models and calculation codes developed be verified with critical experiments and actual operating data.

Boiling Water Reactors

SL-1 Accident and Its Result

January 3, 1961, a nuclear excursion occurred at the Stationary Power Plant No. 1 (SL–1) at the National Reactor Testing in Idaho, causing the death of one Navy and two Army tech- who were working on the reactor. This was the first fatal r reactor accident in Commission history. The cause of the nt has not yet been clearly determined.

SL–1 was a boiling water reactor designed to operate with d uranium aluminum-clad fuel. It was moderated and cooled ural circulation of light water. The reactor was operated as a pe of a facility that could be operated at a remote site for three without refueling. It produced 200 kilowatts of electricity kilowatts equivalent space heat.

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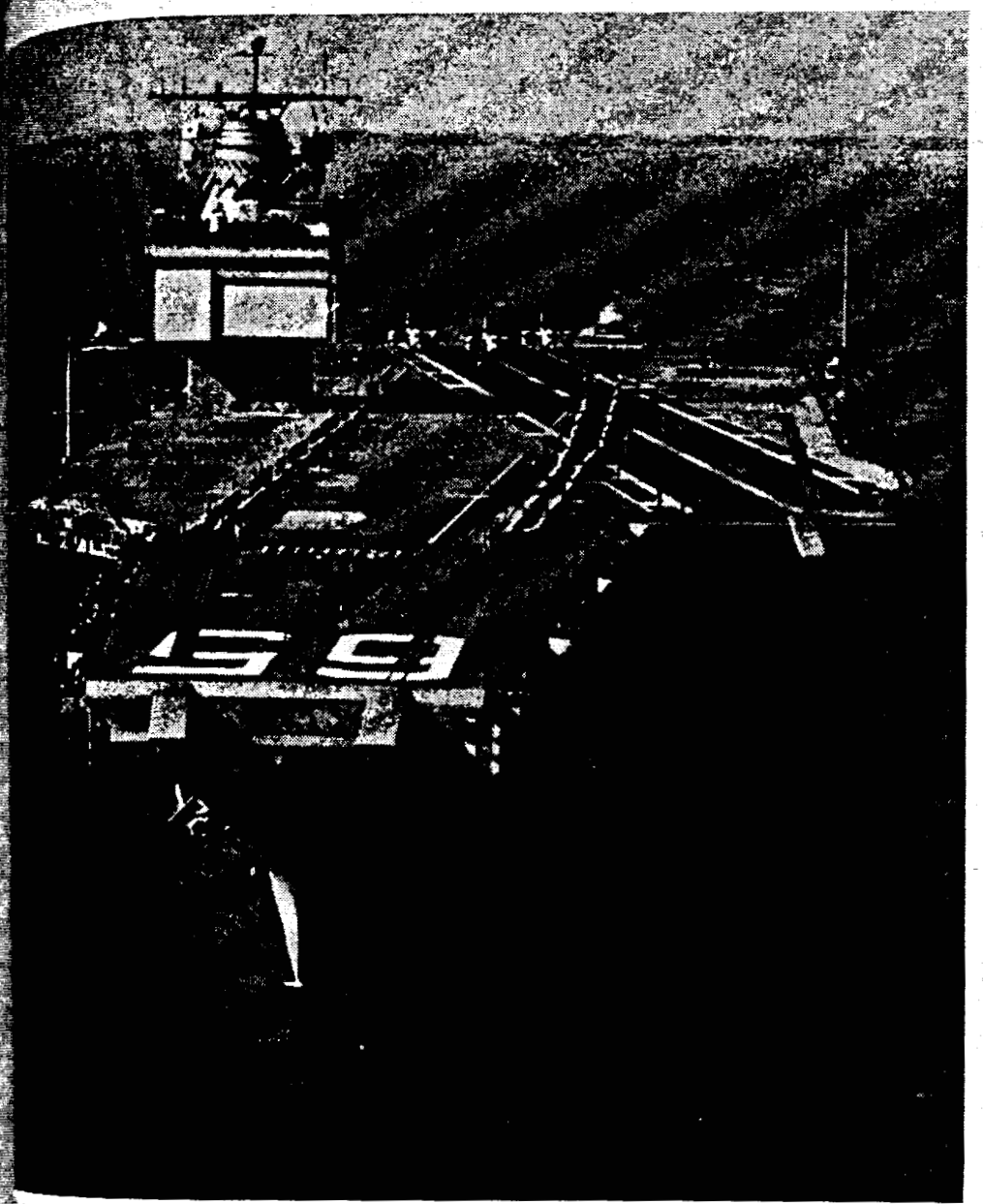
ll Submarine Reactor (S1C)

The Small Submarine Reactor land-based prototype, designed for lication to a small attack submarine, is located at Windsor, Conn. eration of this highly instrumented plant was continued in 1961 to luate design and performance characteristics. Work was initiated a test loop which will be placed in operation in 1962 to support ent technology development work. An *S1C* reactor is used in the ter-killer submarine *Tullibee*, which was commissioned in ember 1960.



and Maneuverable. The nuclear-powered aircraft carrier *Enterprise*, com- ned on November 25, surpassed all design expectations for speed and verability during her sea trials. The 86,500-ton, 1,101-foot long carrier ed in excess of 25 miles an hour and "handled like a destroyer on turns" the trials. The carrier uses eight pressurized water reactors for propul- and other shipboard power.

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Large Ship Reactor (A1W)

Results of test operations with the *A1W* prototype during the year have supported the design, construction, and test programs for the eight-reactor plant of the aircraft carrier *Enterprise* and the two-reactor plant of the guided missile cruiser *Long Beach*. They also have provided design information for future surface ship nuclear propulsion plants.

The A1W plant, a two-reactor prototype, located at the National Reactor Testing Station, provides facilities for the development and testing of a two-reactor power plant and associated equipment suitable for propulsion of large naval surface ships. The plant also provides a means for analysis and evaluation of dual reactor plant performance and for periodic physics tests.

Frigate Reactor Prototype (D1G)

The Frigate Reactor Prototype (*D1G*), located at West Milton, N.Y., consists of a section of a frigate hull containing one reactor, with its associated steam generating equipment, and engine room machinery for operating one shaft of a propulsion plant. A two-reactor nuclear propulsion plant (D2G) using two shafts is being installed in the frigate *Bainbridge*. The D1G construction work has been completed and an extensive test program has been started to confirm the acceptability of the D1G design. Criticality is scheduled for early 1962. Results of this test program are being applied to the design of the nuclear propulsion plant of the *Bainbridge*.

Natural Circulation Reactor (S5G)

Construction of the land prototype *S5G* plant is underway at the National Reactor Testing Station, with completion scheduled for late 1963. Design and development work for the S5G continued at the Commission's Knolls Atomic Power Laboratory, Schenectady, N.Y., which is operated for the Commission by the General Electric Co. The natural circulation concept promises advantages over the current pressurized water reactors for submarine application because of its inherent safety, plant simplification, and increased reliability.

Single Reactor Destroyer Plant (D1W)

Development of a single-reactor propulsion plant (D1W) for use in destroyer-type ships has been undertaken by the Commission in response to a Department of Defense requirement for such a system.

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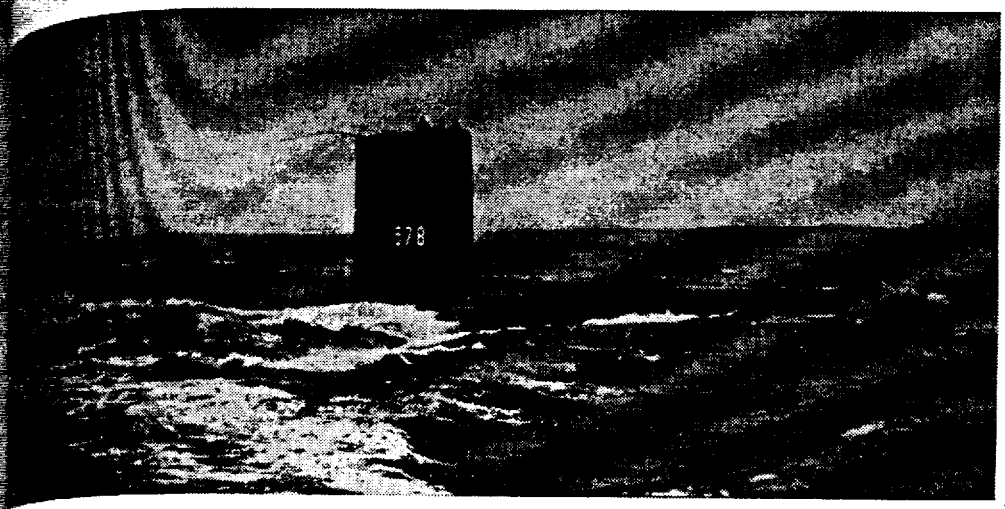
Atomic Power Laboratory at Pittsburgh, operated for the mission by Westinghouse Electric Corp., has been assigned re- sibility for design and development of this plant.

his second generation nuclear propulsion plant for destroyer- ships will utilize a pressurized water reactor. The principal tives of this development will be to design a simplified single- tor propulsion plant of lower cost, for easier maintenance and improved control and safety features for use in destroyer-type s of the future. No prototype plant is planned at present for development effort.



d *Breaker*. The U.S. Navy's first production model nuclear submarine, *Skate*, sailed a record breaking 120,862 miles over a period of 39 months e having her first core replaced during March 1961. Previously, the *Nau-* had traveled 62,560 miles in 26 months on her first core, and 91,325 miles, in 26 months, on her second core. Navy photo shows the *Skate* underway ng Island Sound.

Nuclear Fleet

ty-one nuclear-powered submarines, a nuclear-powered aircraft er, one guided missile cruiser and two guided missile destroyers ate) have been authorized. Twenty-four nuclear submarines, ding eight Polaris missile submarines, are in operation, and 24 have either been launched or are under construction. The High d Submarine Reactor (S5W) is the plant used by most of the ar submarine fleet. All Navy shipboard reactors are of the urized water type.

e first nuclear-powered surface ship, the guided missile cruiser *Beach*, completed sea trials on July 7, and was commissioned eptember 9. The nuclear-powered aircraft carrier *Enterprise* eted sea trials on November 3, and was commissioned November Two A1W-type reactors are used in the *Long Beach* and eight in

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the *Enterprise*. The frigate *Bainbridge*, to be powered by two D2G type reactor plants, was launched April 15, 1961, and is scheduled for sea trials in mid-1962.

As of November 30, 1961, nuclear powered submarines had steamed approximately 1,358,663 miles.

The status of the shipbuilding program for nuclear powered ships authorized by Congress is summarized in table 1.

TABLE 1.—NUCLEAR POWERED NAVAL SHIPS

Submarines and surface ships [1]	Type	Status	Shipbuilder [2]
SSN571 Nautilus	Attack	Operating	Electric Boat
SSN575 Seawolf	do	do	Do.
SSN578 Skate	Small attack	do	Do.
SSN579 Swordfish	do	do	Portsmouth
SSN583 Sargo	do	do	Mare Island
SSN584 Seadragon	do	do	Portsmouth
SSN585 Skipjack	Fast attack	do	Electric Boat
SSN586 Triton	Attack	do	Do.
SSG(N) 587 Halibut	Regulus missile	do	Mare Island
SSN588 Scamp	Fast attack	do	Do.
SSN589 Scorpion	do	do	Electric Boat
SSN590 Sculpin	do	do	Ingalls
SSN591 Shark	do	do	Newport News
SSN592 Snook	do	do	Ingalls
SSN593 Thresher	do	do	Portsmouth
SSN594 Permit	do	Launched 7/1/61	Mare Island
SSN595 Plunger	do	Launched 12/9/61	Do.
SSN596 Barb	do	Under construction	Ingalls
SSN597 Tullibee	Hunter-killer	Operating	Electric Boat
SSB(N)598 Geo. Washington	Polaris missile	do	Do.
SSB(N)599 Patrick Henry	do	do	Do.
SSB(N)600 Theo. Roosevelt	do	do	Mare Island
SSB(N)601 Robert E. Lee	do	do	Newport News
SSB(N)602 Abraham Lincoln	do	do	Portsmouth
SSN603 Pollack	Fast attack	Under construction	New York Shipb.
SSN604 Haddo	do	do	Do.
SSN605 Jack	do	do	Portsmouth
SSN606 Tinosa	do	Launched 12/9/61	Do.
SSN607 Dace	do	Under construction	Ingalls
SSB(N) 608 Ethan Allen	Polaris missile	Operating	Electric Boat
SSB(N) 609 Sam Houston	do	do	Newport News
SSB(N) 610 Thomas Edison	do	do	Electric Boat
SSB(N)611 John Marshall	do	Launched 7/15/61	Newport News
SSN612 Guardfish	Fast attack	Under construction	New York Shipb.
SSN613 Flasher	do	do	Electric Boat
SSN614 Greenling	do	do	Do.
SSN615 Gato	do	do	Do.
SSB(N)616 Lafayette	Polaris missile	do	Do.
SSB(N)617 Alexander Hamilton	do	do	Do.
SSB(N)618 Thomas Jefferson	do	do	Newport News
SSB(N)619 Andrew Jackson	do	do	Mare Island
SSB(N)620 John Adams	do	do	Portsmouth
SSN621 Haddock	Fast attack	do	Ingalls
SSB(N)622 James Monroe	Polaris missile	do	Newport News
SSB(N)623 Nathan Hale	do	do	Electric Boat
SSB(N)624 Woodrow Wilson	do	do	Mare Island
SSB(N)625 Henry Clay	do	do	Newport News
SSB(N)626 Daniel Webster	do	do	Electric Boat
SSB(N)627	do	Authorized	Newport News
SSB(N)628	do	do	Electric Boat

See footnotes at end of table.

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TABLE 1.—NUCI

Submarines and surface ships
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SSN(N)632
SSN(N)633
SSN(N)634
SSN(N)635
SSN(N)636
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SSN639
CGN(N)9 Long Beach
CVA(N)65 Enterprise
DLG(N)25 Bainbridge
DLG(N)35

[1] Westinghouse is listed as th
DLG (N) which is General E
[2] Electric Boat—Electric Boat
Portsmouth—Portsmouth Nav
Mare Island—Mare Island Na
Newport News—Newport Ne
Bethlehem—Bethlehem Steel
Ingalls—Ingalls Shipbuilding
New York Ship—New York S

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Nuclear Propulsion f

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TABLE 1.—NUCLEAR POWERED NAVAL SHIPS—Continued

Submarines and surface ships [1]	Type	Status	Shipbuilder [2]
	Polaris missile	Authorized	Mare Island
	do	do	Newport News
	do	do	Electric Boat
	do	do	Newport News
	do	do	Electric Boat
	do	do	Mare Island
	do	do	Newport News
	do	do	Portsmouth
	Fast attack	do	Unassigned
	do	do	Do.
	do	do	Do.
	Guided missile cruiser	Operating	Bethlehem
USS Long Beach	Aircraft carrier	do	Newport News
USS Enterprise	Guided missile destroyer (frigate).	Launched 4/15/61	Bethlehem
USS Bainbridge	do	Authorized	Unassigned
USS			

[1] Westinghouse is listed as the reactor designer for all vessels except for the *Triton*, *Bainbridge*, and USS (N) which is General Electric, and for the *Tullibee* which is Combustion Engineering.
[2] Electric Boat—Electric Boat Division of General Dynamics Corp., Groton, Conn.
Portsmouth—Portsmouth Naval Shipyard, Portsmouth, N.H.
Mare Island—Mare Island Naval Shipyard, Vallejo, Calif.
Newport News—Newport News Shipbuilding and Dry Dock Co., Newport News, Va.
Bethlehem—Bethlehem Steel Co., Shipbuilding Division, Quincy, Mass.
Ingalls—Ingalls Shipbuilding Corp., Pascagoula, Miss.
New York Ship—New York Shipbuilding Corp., Camden, N.J.

AIRCRAFT REACTORS PROGRAM

Nuclear Propulsion for Manned Aircraft

The Commission-Air Force aircraft reactors program continued work on both the direct and indirect cycle nuclear propulsion programs until March 28 when the President, in his budget message to Congress, announced his decision to terminate the Aircraft Nuclear Propulsion (ANP) program. Notices were issued on March 30 to the ANP contractors of the President's decision with instructions to close out all work, prepare final reports, and initiate appropriate actions for disposition of equipment, materials, and facilities. Termination activity was about completed at the end of the year.

After the program's termination, all work oriented toward actual aircraft application was cancelled. The 10 megawatt (thermal) lithium-cooled reactor experiment, planned for the indirect cycle approach, was re-designed and re-oriented to an advanced high temperature reactor experiment to further lithium-cooled reactor technology. A high-temperature materials program was initiated at the ANP contractor sites to advance materials technology and to utilize the capabilities and experience of the personnel at these sites.

The direct cycle approach to nuclear propulsion for manned aircraft was being developed by the General Electric Co. under Commis-

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sion contract, at Evendale, Ohio, and at the National Reactor Testing Station (NRTS) in Idaho. Before the termination, research and development work had continued on ceramic fuel elements for the Advanced Core Test (ACT) Reactor Experiment. It had been planned to operate the ACT reactor in the Flight Engine Test Facility at NRTS in late 1962. Design of the reactor, coupled with a high air flow X–211 turbojet engine, had been completed, and ACT reactor components were under test.

The indirect cycle approach was being developed, under Commission contract, for aircraft propulsion application by the Pratt and Whitney Aircraft Division of the United Aircraft Corp., at the Connecticut Aircraft Nuclear Engine Laboratory (CANEL), Middletown, Conn. Research and development work on a 10 megawatt high-temperature reactor had been continued in the first quarter of 1961, and liquid-metal loop components were in fabrication prior to development and testing. Partial and full-scale components were being tested. Design work had been initiated on the objective power plant consisting of high power liquid lithium-metal-cooled reactors coupled to modified turbojet engines. Development of advanced structural and fuel element materials and design concepts of unit-shielded higher power and fast reactors was underway at the time of termination.

Design and performance studies to develop airframe propulsion system concepts capable of meeting the performance requirements of the Department of Defense also had been continued until the end of March by the airframe contractor, the Convair Div. of General Dynamics Corp. The Oak Ridge National Laboratory had continued to support both cycle approaches in the areas of reactor physics, materials development, chemistry, thermodynamics, shielding and radiobiology. After program termination, this basic work was reoriented to support the SNAP and other high priority programs.

HIGH PERFORMANCE REACTOR PROGRAM

Following the cancellation of the Aircraft Nuclear Propulsion (ANP) program, the Commission executed a contract on May 1 with Pratt & Whitney (P&W) for the conduct of research and development on a high-performance, high-temperature reactor experiment based on the materials and reactor technology previously developed by P&W under the ANP program. Development of high performance reactor systems is a natural outgrowth of the previous work on ANP reactors and is a necessary part of preparation for a variety of future applications where high performance (e.g., high temperature, high power density, high thermal efficiency, long lifetime) is required.

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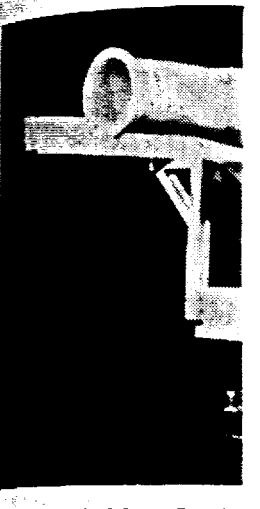

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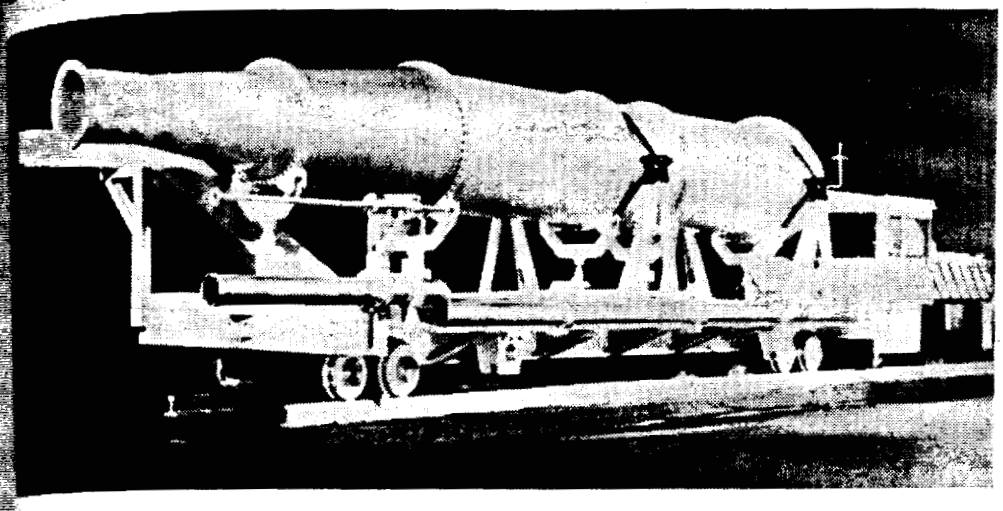
The current reactor program at P&W has as its objective the development, engineering design, fabrication, and test operation of a high-performance reactor experiment which will provide engineering data on a high-temperature lithium-cooled reactor fabricated of a niobium-zirconium alloy.

During the past year, much of the preliminary design of the reactor experiment and facility was accomplished. After the termination of the ANP work, many of the component development programs initiated previously under the ANP project were continued with appropriate modifications, while new development programs were started as required by significant design changes.

Although this reactor experiment is not being designed to satisfy a specific application, the operation of such a reactor system will demonstrate the high-temperature, high-performance capability of this technology. It will also provide the type of performance information necessary for the development of reactor systems for such applications as space power and mobile ground power.



Tory IIC Model. Photo shows a model of the Tory IIC, an advanced flight type reactor in the PLUTO program, mounted aboard its test vehicle. To the rear of the reactor is a model of the remote-controlled locomotive which will be used to move the experimental device around the Commission's Nevada Test Site. The Tory series of reactors are experiments being conducted by the Commission and the Air Force to demonstrate the feasibility of a nuclear ramjet engine for use in strategic missiles.

NUCLEAR RAMJET PROPULSION (PROJECT PLUTO)

Project PLUTO is designed to demonstrate the feasibility of a nuclear ramjet engine for use in strategic missiles. The nuclear ramjet promises the unique capability for supersonic flight over long distances at low altitudes. The project is a coordinated effort of the Commission and the Air Force, the Commission being responsible for development of the reactor, the Air Force for the propulsion engine, the flight vehicle and associated components.

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The reactor is being developed by the Lawrence Radiation Laboratory at Livermore, Calif., which is operated for the Commission by the University of California. The laboratory's program, in addition to research in high temperature materials, ceramic fuel elements, control systems, and neutronics of a hitherto largely unexplored reactor concept, includes a major effort in designing, fabricating, assembling, and ground testing at the Nevada Test Site (NTS) two reactors designated Tory IIA–1 and Tory IIC.

Tory IIA–1 was operated at the test site on May 14, September 25, October 5 and 6, 1961. During these power runs, temperatures in excess of 2,000° F. were attained in the reactor core. At year's end, the reactor was being disassembled in the special shielded disassembly building at the NTS to permit detailed studies of its components. This signaled the end of small reactor tests in this feasibility program.

The ultimate objective in the feasibility program is the testing of the Tory IIC flight-type reactor. The final design of the Tory IIC was completed during 1961 by the laboratory, and component procurement initiated. The Tory IIC was designed for power, temperatures, power density and size suitable for a propulsion system for low altitude supersonic flights. The reactor control system and reflector are of the flight type. Fuel elements for the Tory IIC are being manufactured by Coors Porcelain Co., Golden, Colo.

During fabrication and assembly of the reactor, the test facilities at the Nevada Test Site will be augmented to meet the Tory IIC experiment test requirements. Diversified Builders, Inc., and Industrial Contractors, Inc. (joint venture), of Paramount, Calif., were awarded a $5,975,000 contract in November to expand and modify the PLUTO test facilities. Construction is expected to take 14 months. Norman Engineering Co., Los Angeles, is architect-engineer.

The Marquardt Corp., Van Nuys, Calif., renders engineering support to the Lawrence Radiation Laboratory Tory test program. A number of other companies have contributed significantly in support of materials research, controls development, and test vehicle and component design and fabrication.

Simultaneous with the Commission program, the Air Force during 1961 has continued its support of engineering studies on ramjet engine design, guidance of vehicles at high speeds, hazard studies of testing and operation, and aerothermodynamic studies to outline iteration problems of the nuclear reactor, the other ramjet components, and the air frame. This work is being performed primarily by Marquardt and Chance-Vought Aircraft, Inc., Dallas, Tex.

Upon demonstration of feasibility of Tory IIC, the next logical step in the program would be fabrication and ground testing under simulated flight conditions of a prototype nuclear ramjet engine.

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Part Three

Major Activities in the Atomic Energy Programs

January–December 1961

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MILITARY APPLICATION

The Commission's program of developing nuclear energy for military applications and related work during 1961 included:

The first U.S. nuclear weapons test in two years and 11 months place underground at the Nevada Test Site on September 15, ing this nation's voluntary suspension of tests. By year's end, underground tests at the site had been announced.

Two new research and test reactor facilities were put into operation aid in studying radiation effects on materials and components and obtaining basic physics and chemistry information necessary for apons development.

Preliminary work for a series of nuclear and high explosive detona- was undertaken in programs being carried out jointly with the artment of Defense to effect a capability of detecting and identify- nuclear detonations.

WEAPONS DEVELOPMENT AND PRODUCTION

apons Development

During the latter part of 1961, an accelerated effort was applied weapons development at each of the three weapons laboratories, is, Sandia Corp., Los Alamos, and Livermore. Also during 1961, ding on a broad base of general research in each of the labora- es, new weapons designs were produced to meet specific Depart- t of Defense weapons system requirements. Improvements in gn were also directed at better reliability, greater safety, and in- sed effectiveness per pound of warhead weight. A considerable t was also directed to a study of the comparison of weapons de- pment possible without testing, as compared to what could be mplished either limited to underground testing only or to testing ny environment without limitation. New effort was also applied e design of weapons diagnostic instrumentation that would permit ter flexibility in the choice of method of weapons testing.

pons Tests

September 1, 1961, the Soviets abruptly and cynically broke the torium on nuclear testing by launching an extensive and varied

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nuclear test series of about 50 atmospheric detonations with a total yield of about 120 megatons. This series obviously had required extensive preparations during the negotiations for a test ban. Shortly thereafter, on September 15, 1961, the United States initiated a weapons test program underground at the Commission's Nevada Test Site. By the end of the year, the Commission had announced eight nuclear weapons tests, all of low yield, and all conducted underground.

Underground testing is limited to the lower yield devices (up to some tens of kilotons at present) and certain types of tests, particularly some effects tests, cannot be made in this way at all. Hence, steps were taken to prepare for a series of tests in the atmosphere in the event the President should decide to expand the test effort in this way.

While important development information with respect to nuclear weapons design was discovered in the course of the underground tests, these tests also revealed that testing underground is a slower and more expensive process than had previously been assumed. It has proved to be more difficult to diagnose some of the results of development tests; operational difficulties such as post-shot re-entry and re-use of partially contaminated tunnels were continuing factors in delaying the test program.[1] The Commission and its contractors are vigorously attacking these problems and marked progress is being made.

Weapons Production

Under Presidential authorization, the production of nuclear weapons by the Atomic Energy Commission continued in 1961. The production effort was responsive to Department of Defense requirements such as providing warheads for new weapons systems, and for bombs that would permit a greater flexibility in methods of delivery. The new weapons produced during 1961 were of considerably more modern design with improved effectiveness, reliability and safety over weapons previously in the stockpile. The program for retirement of obsolescent weapons was also continued.

Weapons Facilities

Construction began in November on a $3.5 million specialized plant at Oak Ridge, Tenn., to meet weapons production requirements.

[1] The necessity of limiting the exposures of tunnel workers to radiation required the re-assignment of some workmen to areas at NTS where no radioactivity is present. The highest exposure to any tunnel worker was approximately 8 rem for the calendar year 1961. In no case did an individual's exposure carry him above the lifetime formula 5 (N–18) rem where N is the age of the individual at his next birthday. This formula has been recommended by the Federal Radiation Council and approved in 1960 by the President as protection guidance for radiation workers.

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The Lawrence Radiation Laboratory acquired a STRETCH 7030 computer in October. A similar computer had been delivered to the Los Alamos Scientific Laboratory earlier in the year. These new computers will increase the capacity of the laboratories to solve problems requiring speed and large memory storage.

The Commission's water-impact test activities at the Salton Sea Base ceased during the year and disposal of facilities will be made through the General Services Administration. Future water entry testing of inert (non-nuclear) weapons shapes will be conducted at other Government installations. The Salton Sea Base had been established in 1941 as a Navy facility for torpedo and skip bombing practice. It was taken over by the Commission in 1947.

Radiation Environment Facilities

Two new facilities for study of the effects of radiation environments on material and components have been installed at Sandia Laboratory. In the past, the Van de Graaff Accelerator facility and radioactive sources have been used. The new facilities, the Sandia Pulsed Reactor Facility (SPRF), and the Sandia Engineering Reactor Facility (SERF), will be used to extend and accelerate studies in the basic physics and chemistry of neutrons and gamma ray bombardment phenomena. They will similarly extend and accelerate engineering studies of the radiation tolerance of materials, components, and electronic circuits.

The Sandia Pulsed Reactor makes it possible to study the response of materials, components, and electronic circuits to transient radiation fields. Associated with the SPRF is a pulsed X-ray device which may be used to segregate the effects due to high-energy electromagnetic radiation from those caused by a combined neutron and gamma ray bombardment. The SPRF facility will also be extensively used in studies conducted for Department of Defense agencies and their contractors.

The SERF is designed for carrying out a variety of radiation effects studies. In this facility, large components can be irradiated in combination with other environments such as high or low temperature, vacuum, or shock. The facility includes two cryostats for use in fundamental studies of neutron bombardment phenomena at very low temperatures. It is extremely flexible in that other experimental devices may be installed with relative ease. In addition,

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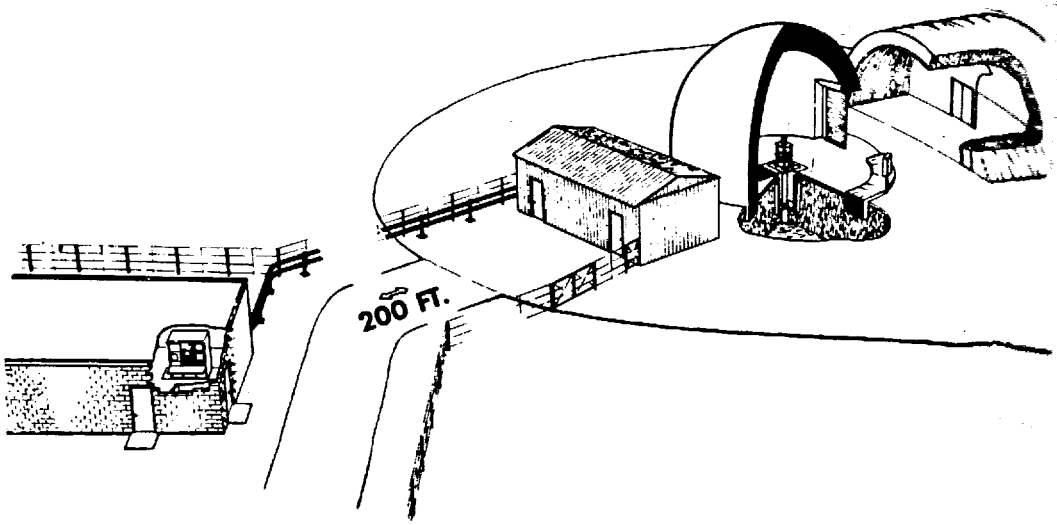
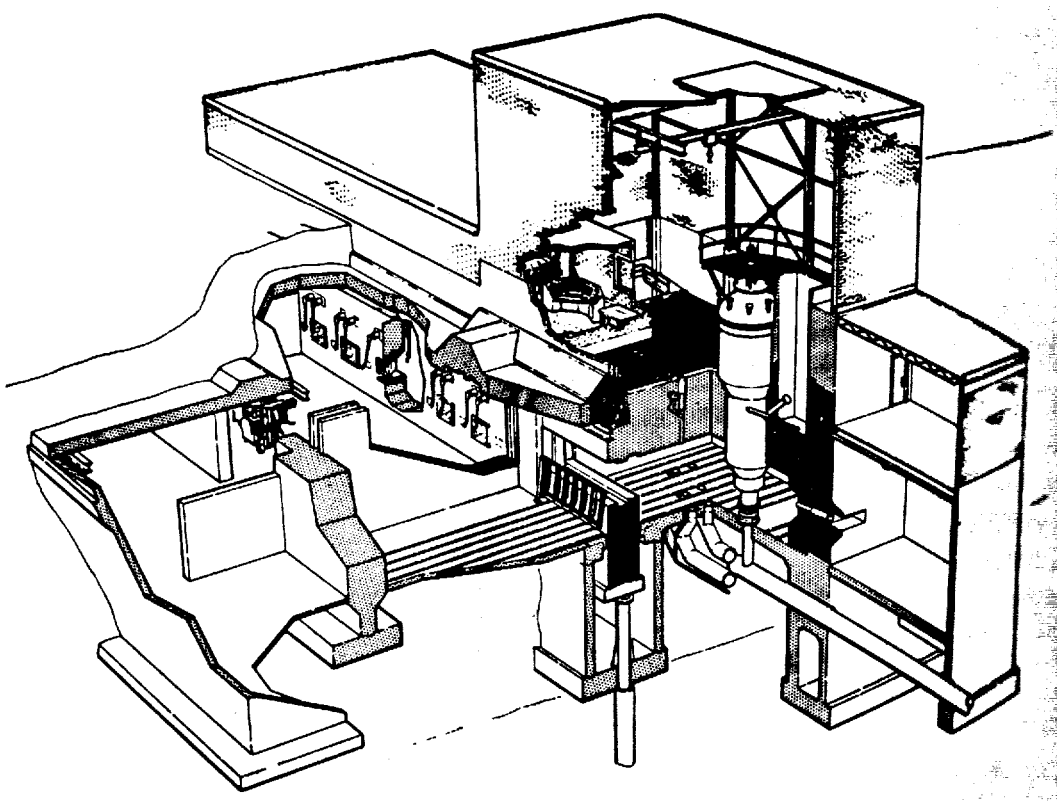


New Sandia Reactors. Two new facilities have been added at the Commission's Sandia Corp. laboratories in New Mexico that will be used to extend and to accelerate studies in the basic physics and chemistry of neutrons and gamma ray bombardment phenomena. Drawing *above* shows the Sandia Pulse Reactor Facility (SPRF) which will be used to study the response of materials and electronic circuits to transient radiation fields. The control room (left) will be located several hundred feet from the reactor (under half-dome) to protect personnel from the massive pulses of radiation. Drawing *below* shows the major parts of the Sandia Engineering Reactor facility (SERF) which will be used in radiation effects studies on large components under varying environments.



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These two reactor facilities not only extend the Laboratory's research and experimental capacities in military programs but may also find application in civilian research.

DETECTION OF NUCLEAR EXPLOSIONS

Studies continued on ways and means to improve detection techniques and systems, both for underground and space applications.

The Commission is participating in the *VELA* program, which is coordinated by the Department of Defense, to improve the capability of detecting and identifying nuclear detonations for the purpose of developing an adequate system capable of monitoring a nuclear test ban treaty.

Vela-Uniform Program

The purpose of the *Vela-Uniform* Program is the development of techniques for improving the capability of detecting and identifying underground nuclear explosions. The Commission is involved primarily in making available large seismic signal sources for the technical measurements to be obtained. In this connection it is responsible for over-all program coordination; emplacement and detonation of all nuclear devices; yield and limited technical measurements; public safety, and any on-site logistical and construction support services required by the technical agencies involved.

With the resumption of nuclear weapons development tests, Vela-Uniform measurements are being made on underground detonations. In addition to data obtained from the late 1961 weapons tests, valuable information was obtained from the December 10 Project Gnome experiment of the Plowshare program.

The Commission's Office of Field Operations (formerly Office of Test Operations) has performed an exploratory program at the Tatum Salt Dome in Mississippi to verify its suitability for use in the Dribble series. Project Dribble would consist of a series of nuclear explosions to be conducted in a salt dome to provide information on decoupling (i.e., use of a large underground cavity as an explosion chamber to reduce the seismic signals generated) and data comparison with underground nuclear detonations in other media. Programs are being planned to assure public safety of the planned nuclear detonations. Because of the priority of the weapons tests program, scheduling of the Dribble series is in abeyance. Data obtained from the seismic

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measurements made on weapons tests detonations at the Nevada Test Site will have an effect on the final planning for this program.

Vela-Hotel Program

The Commission, through its Sandia Laboratory, the Los Alamos Scientific Laboratory, and Lawrence Radiation Laboratory (Livermore)[2] is participating in the Department of Defense *Vela-Hotel* Program, a research and development effort aimed at developing satellite-based instruments and systems to detect nuclear explosions in space.

The current program now calls for five *Atlas Agena* launchings in 1963–1964, each to put two instrumented satellites into earth orbits. In addition, instrumentation will be included on a variety of other space vehicles to measure background radiation at various levels above the earth.

The program of developing instrumentation for satellites for the Atlas Agena launchings is a cooperative effort by Los Alamos Scientific Laboratory and Sandia Laboratory. Radiation detectors for neutrons, gamma rays and X-rays will be employed. The Lawrence Radiation Laboratory (Livermore) has participated in the background measurement program. As part of this work, instrumentation has been flown on several Discoverer vehicles with special emphasis on measurement of X-ray bursts.

Vela-Sierra Program

The Los Alamos Scientific Laboratory is participating in the Department of Defense *Vela-Sierra* program to develop ground-based instruments for possible detection of nuclear explosions in space. An experimental detector station using air fluorescence as a signal was designed, fabricated, and field tested in Greenland. This system is based on the detection of the fluorescence of nitrogen when bombarded by X-rays. Design criteria for an operational station were also completed during the year, and an experimental direct-optical detection station was built and is being tested. This method utilizes an optical system to measure the visible light produced by a nuclear detonation.

[2] The Lawrence Radiation Laboratory, which is contract-operated for the Commission by the University of California has facilities at Livermore, Calif., as well as on the University's Berkeley campus. The Livermore facilities are primarily concerned with research and development on matters associated with nuclear explosives, and research on thermonuclear (fusion) reactors. While some thermonuclear work is also done at the Berkeley facilities, most of the effort at this site is in the life sciences, physics, and chemistry fundamental research areas. Throughout this report, Berkeley or Livermore is parenthesized to indicate at which of the Lawrence Radiation Laboratory sites the work mentioned is being done.

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al Defense Agreements

changes of information under Agreements for Cooperation with nations for mutual defense purposes, reported in the Annual rt to Congress for 1960,[3] continued during 1961. The United -United Kingdom Agreement for Cooperation, which is conably broader than other agreements, involves the exchange of ified information on nuclear weapons and the exchange of visits en scientists of the two countries.

e United States has mutual defense agreements in effect with ralia, Canada, France, the Federal Republic of Germany, Greece, Netherlands, Turkey, Italy, the United Kingdom, and the North tic Treaty Organization (NATO). (The effective dates of these ments are shown in Table 4 of the International Activities sec- of this report.)

RAW MATERIALS

ring 1961, the Commission continued to renegotiate and extend omestic concentrate purchase arrangements in accordance with ly announced programs. Of the total quantity of uranium esti- d to be purchased after July 1, 1961, under the announced domes- programs, approximately 90 percent is now included in new mill acts and contract extensions extending beyond March 31, 1962, n most cases to December 31, 1966. In order to obtain a more rm rate of delivery, some contract extensions involved the de- until later years of uranium scheduled for delivery prior to The year's highlights for the Commission's raw materials rm include:

Uranium concentrate deliveries totaled 30,325 tons of uranium (U_3O_8) of which domestic sources accounted for 57 percent; s from Canada accounted for 29 percent of the total concen- received, and overseas receipts, 14 percent.

At the year end, the Commission had 25 domestic contracts for ocurement of uranium from 27 mills, one of which is nearing tion in the Shirley Basin Area of Wyoming. Nineteen of the tracts extend through 1966, three have earlier termination dates e of limited supplies of eligible ore and three contract exten- are in the process of negotiation. The mill at Lakeview, Oreg., ded operations during 1960 for lack of ore.

One new processing mill, the first in Texas, began operations the year.

[3] p. 125.

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- Production of uranium from Florida phosphates was terminated during the year after operations showed the feasibility of this source as a reserve for the future.
- Uranium miners were granted an exemption from the need to be licensed to transfer uranium ore from mine to mill, or to buying stations.
- Recent exploration discoveries, along the Idaho-Montana border, of large veins of the mineral thorite, may give the United States a thorium reserve of 100,000 tons. There is a possibility that several times this quantity may eventually be developed.
- The joint United States-United Kingdom Combined Development Agency contract for purchase of South African uranium was replaced by two separate contracts. The new AEC-South Africa contract provides for a reduction in price and a minor deferral of deliveries.

Domestic Activities

Procurement Record

Over the past ten years, the Commission's procurement of uranium concentrate has shifted from a heavy dependence upon foreign suppliers to a situation where domestic producers currently supply 57 percent of the total receipts of U_3O_8. The table below shows the procurement on a *fiscal year* basis.

TABLE 1.—PROCUREMENT RECORD FOR URANIUM CONCENTRATES

	Domestic		Canada		Overseas		Total tons U_3O_8
Fiscal years	Tons U_3O_8	Percent of total	Tons U_3O_8	Percent of total	Tons U_3O_8	Percent of total	
1952	830	23	210	6	2,620	71	[illegible]
1953	990	34	225	8	1,685	58	[illegible]
1954	1,450	31	690	15	2,550	54	[illegible]
1955	2,140	36	830	14	2,970	50	[illegible]
1956	4,200	40	1,590	15	4,650	45	[illegible]
1957	7,580	47	3,370	21	5,210	32	[illegible]
1958	10,245	39	9,475	36	6,655	25	[illegible]
1959	15,160	45	13,505	41	4,660	14	[illegible]
1960	16,565	48	13,445	39	4,570	13	[illegible]
1961	17,760	55	10,250	32	4,250	13	[illegible]
Totals	76,920	45	53,590	32	39,820	23	[illegible]

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ected Uranium Receipts

Projections of uranium concentrate deliveries from domestic, adian, and overseas sources under existing commitments for the od July 1, 1961, through December 31, 1966, show that there will drop from approximately 30,000 tons of U_3O_8 received in fiscal 1962, to about 18,000 tons in fiscal year 1966. In this latter od, receipts from overseas sources will be about 1,600 tons and adian deliveries will have been reduced to about 500 tons.

The forecast, as shown in the following chart, is based upon con- ts and allocations assigned, or to be assigned, to domestic mining perties. No short-falls in foreign deliveries are anticipated, bar- major economic or political disturbances. A large percentage omestic deliveries is equally firm. However, a considerable num- of production allocations are assigned to properties which may e marginal or submarginal. Consequently, total projected stic deliveries may fall short several thousand tons as a result ailure to produce the full amount covered by allocations and ing contracts. Delivery short-falls have occurred in the past as ult of delays in bringing mines into full production, lower grade than anticipated, failure of ore supply, or milling problems.

omestic production, which is estimated at 17,820 tons in fiscal year will decline to about 16,000 tons per year by 1965 and remain this level through 1966. Foreign procurement, however, will rapidly after fiscal year 1963 and will be only 2,100 tons in fiscal 1966. Under the present projected commitments, for the period 1, 1961, through December 31, 1966, the domestic uranium pro- s will supply approximately 72 percent of the total uranium hases.

ium Production

anium ore production in the United States totaled approximately illion dry tons during 1961, as compared to 8.0 million tons in revious 12 months. Receipts of uranium oxide (U_3O_8) in con- ates for the year totaled 17,410 tons.

mestic ore reserves at the end of 1961 were reduced to 74 million as compared with 82 million tons reported at the end of 1960. dition, 1.3 million tons of ore were in Government and private piles. The reduction in ore reserves reflects the mining of imately 8 million tons during 1961. Ore reserve estimates ing reviewed in the light of new information which has been ped in the course of mining.

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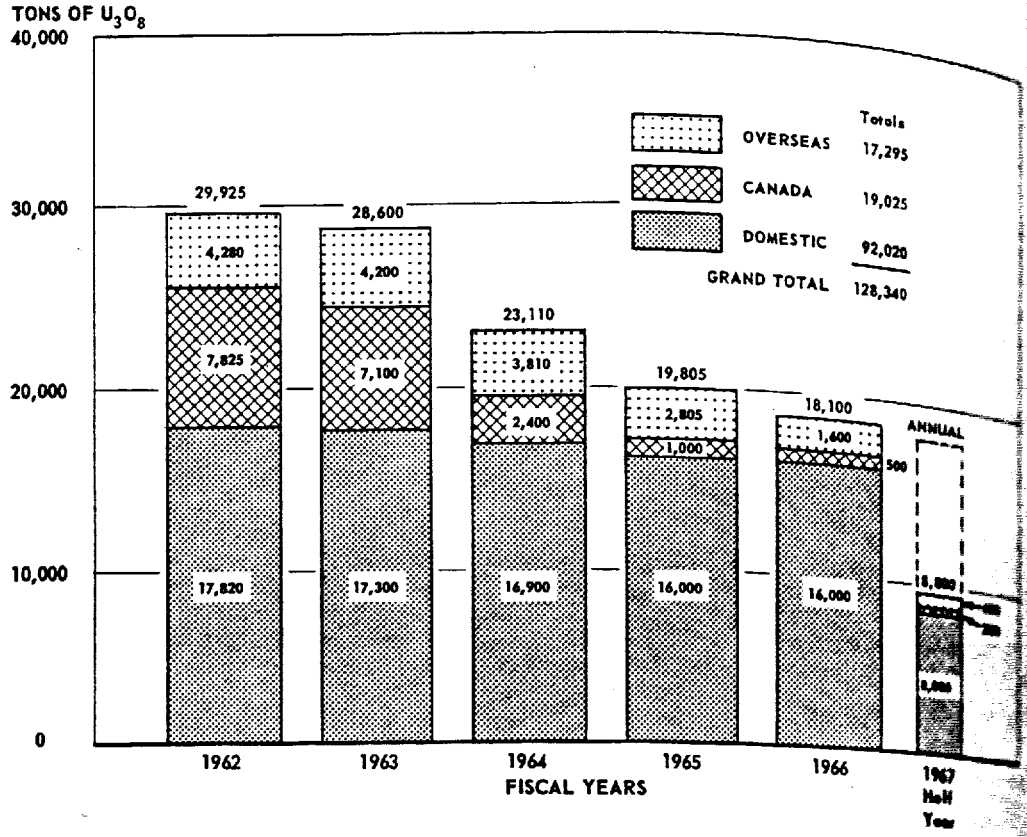
PROJECTED URANIUM RECEIPTS



Production Allocations

The domestic uranium concentrate procurement program for the period March 31, 1962–December 31, 1966, was limited by the Commission's announcement of November 24, 1958,[4] to the purchase of appropriate quantities of uranium in concentrates derived from ore reserves developed as of the date of the announcement. Mill contracts and contract extensions negotiated pursuant to the November 24, 1958, announcement provide that ore processed in the mill for the production of uranium concentrate for sale to the Commission shall be obtained only from properties and in amounts covered by Commission allocations.

In developing the program established November 24, 1958, the Commission recognized that a large number of mining properties contain irregular deposits which, under normal procedures, are not developed far in advance of mining. Most of the small, independent mining operations, as well as a few larger ones, fall in this category. For this type of operation, the Commission announced in February that it will consider using the historical production rate of a mining property, rather than developed ore reserves, as a basis for establishing

[4] See pp. 113–115, Annual Report to Congress (January–December 1960); pp. [illegible] Annual Report to Congress (January–December 1959).

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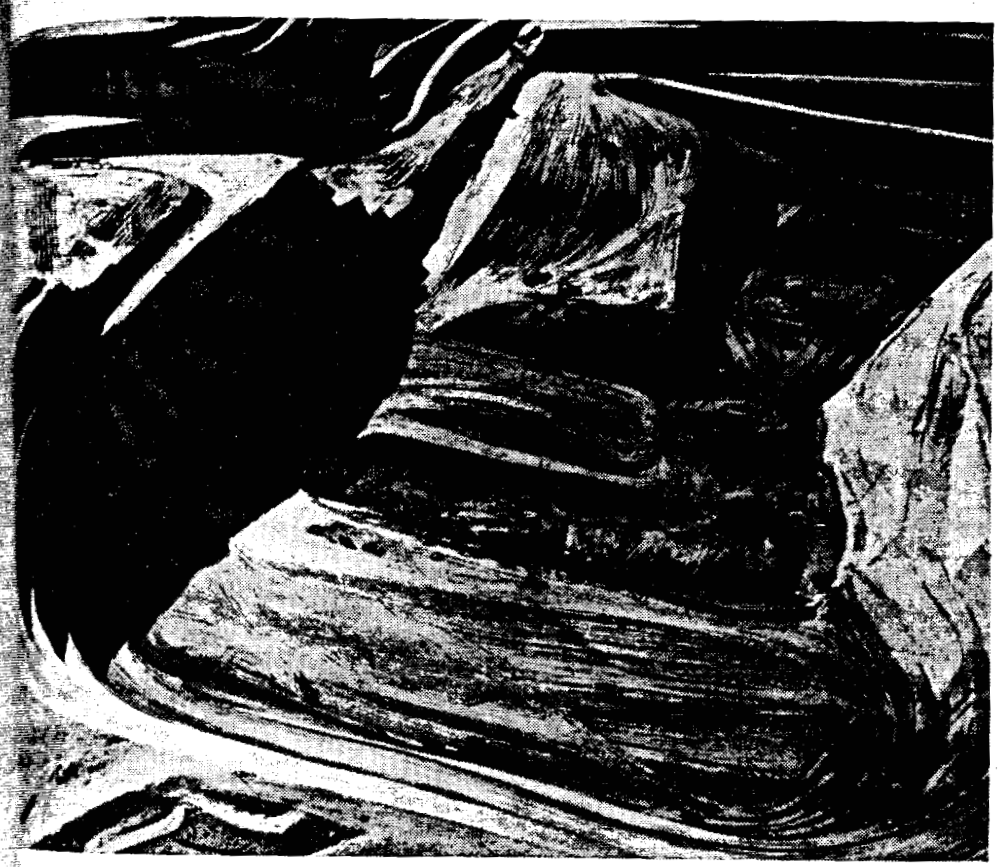
a market. A large number of small mining properties would lify under this announcement. Where a historical production is used, the allocation will relate to ore production over the d July 1, 1956, through June 30, 1960.

llocations covering purchases from most of the larger mining perties have been established and have been incorporated in milling racts.

mall, independently owned mining properties will represent a e percentage of the total number of allocations, but ore reserves ch properties constitute a relatively small proportion of the total. tically all of the active producing properties have been examined the Commission and allocations have been calculated. Ore pur- e contracts between producers and mills for the 1962–1966 period be approved by the Commission to determine that the quantities e delivered and processed are in accordance with established ations.



Uranium Mine. Aerial photo shows the Frazier-Lamac uranium open e of Western Nuclear, Inc. The mine is located in the central Gas Hills Wyoming. It is the largest stripping operation in the Gas Hills area the peak of operations, more than 2,200,000 cubic yards of overburden moved in one month. (Photo courtesy of Riverton Ranger, Riverton,

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Milling Operations

During 1961, the Commission modified and extended six more contracts with ore processing mills to provide an appropriate market in the 1962–1966 period for uranium concentrates produced from reserves developed prior to November 24, 1958. The Petrotomics Co. is building a new mill in Shirley Basin, Carbon County, Wyo., to produce concentrates in the post-1962 period under the November 24, 1958, announcement. The mill, which is expected to be able to treat up to 400 tons of ore a day, is scheduled for completion March 31, 1962.

Of the 25 milling contracts, 19 extend through 1966 and three terminate before 1966 by reason of a limited eligible ore supply. The three remaining contracts due to expire March 31, 1962, which are in the process of negotiation for extension, are:

Company	*Location*	*Capacity in tons per day*
Mines Development, Inc	Edgemont, S. Dak	[illegible]
Rare Metals Corp. of America	Tuba City, Ariz	[illegible]
Vitro Chemical Co	Salt Lake City, Utah	[illegible]

Additional Milling Facilities

On April 2, 1958,[5] the Commission announced a limited expansion of domestic uranium procurement to provide an additional market for ore reserves developed prior to November 1, 1957. The contracting for additional mill capacities under this program in those areas having either no market or an inadequate market was completed during 1960 with the exception of the lignite area of North Dakota-South Dakota for which there is still no ore milling facility. The terms of a contract with International Resources Corp. involving construction of a mill in Bowman, N. Dak., to treat uraniferous lignite were agreed upon by the Commission in October 1960. However, the contract was not executed because of failure of the contractor to arrange financing.

The new 200 ton-per-day uranium mill of Susquehanna-Western, Inc., located near Falls City, Texas, started operations in April. This is the first uranium milling operation in Texas, and will draw on ore reserves developed prior to November 1958, principally in Karnes and Duval Counties.

A list of uranium processing mills as of December 31, 1961, is given in Table 2 on page 177.

[5] See pp. 115–117, Annual Report to Congress (January–December 1960).

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ium from Florida Phosphates

e Commission's contract with U.S. Phosphoric Products Divi- Tennessee Corp., for the production of uranium from Florida phates expired in June and final shipment of uranium was made ly. The operation of the company's plant at East Tampa was ssful and demonstrated that uranium can be produced as a by- uct in the manufacture of triple superphosphate fertilizer at able cost. These operations showed that, should a market de- in the future, byproduct uranium could be produced from da phosphates at a direct cost, exclusive of plant costs, of $8.00 s per pound of U_3O_8. There is a production potential of about tons U_3O_8 per year from current phosphate operations.

ium Miners Exempted from AEC Licensing Regulations

e Commission's source material licensing regulations (Title 10, of Federal Regulations, Part 40) were revised early in the year. r the revised regulations, uranium miners are no longer required ve a Commission license to transfer uranium ores from mine to or to a buying station. Under regulations in effect since 1947, ium miners were required to have a Commission license to transfer fined and unprocessed ores containing source material after it was d. A license still will be required to refine or process uranium including the mechanical upgrading of ores.

ioactive Hazards in Uranium Mills and Mines

anium ore processing mills are Commission-licensed operations ct to Commission regulatory control, including Title 10, Code of eral Regulations, Part 20, "Standards for Protection Against tion." The physical control of concentrations of uranium dust e mill atmosphere, and also of concentrations of radioactive tituents in liquid effluents from the mills, requires continual sur- ance in order to comply with established standards. When neces- the Commission has ordered a mill operator to take steps to ct situations that could be a hazard to the health and safety of yees or the public.

e radioactive hazards of uranium mines are subject to control the provisions of State regulations. The Commission assists

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the State agencies and the Federal agencies concerned with this problem in carrying out environmental surveys and in developing procedures to control the air contamination level in the mines. Commission representatives are also assisting the working group of the Federal Radiation Council in a study of the radiation hazards in uranium mining.

Public Sale of Vanadium Pentoxide

In January, bids were opened on 1.5 million pounds (750 tons) of vanadium pentoxide (V_2O_5) which were offered for sale by the Commission's Grand Junction Office. Successful bidders on 570 tons of the V_2O_5 concentrates were Union Carbide Metals Co. (424 tons), Vanadium Corp. of America (98 tons), and Derby and Co. (48 tons). The average price per pound for the 570 tons amounted to $1.011; the total bid was $1,152,756.60. A bid price of $0.91 per pound was rejected on four lots containing 180 tons of V_2O_5.

The Vanadium Corp. of America was the successful bidder in a previous sale (May 1960) for more than 1.5 million pounds (790 tons) of vanadium pentoxide, at $1.00 per pound V_2O_5.

Vanadium pentoxide is a co-product recovered in the processing of uranium-vanadium ores. The amounts received by the Commission were the result of early contracts under which the Commission agreed to purchase the vanadium when production was in excess of current commercial requirements. This provision was intended to encourage the production of uranium from the treatment of uranium-vanadium bearing ores. Vanadium pentoxide is used principally as an alloying material in steel and as a catalytic agent in the chemical industry.

Thorium Reserves

Recent private exploration in the Lemhi Pass area of Idaho and Montana has revealed the existence of a number of large and persistent veins carrying a relatively high thorium content in the form of thorite. Although drilling and underground development have not been extensive, the large persistent veins have been exposed at frequent intervals for distances of up to 3,000 feet and at elevations ranging from 5,000 to 8,000 feet. Samples indicate a large tonnage of ore averaging in excess of one-half percent ThO_2. On the basis

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eological information and the limited amount of sampling, it ars that these deposits may contain approximately 100,000 tons ThO_2 in ore which would be commercial at current prices. Furmore, the persistence of mineralization in the veins on which exploration has been carried out, and the existence of a large ber of additional but unexplored veins, offer possibility for the tual development of a reserve several times this figure.

rior to the Lemhi Pass development, no important thorium deits had been found in the United States. Reserves had been estied at 20,000 tons of ThO_2 with possibilities of an additional 30,000 These figures related primarily to small deposits or relatively grade deposits of monazite from which it was estimated the cost covery might be approximately $10.00 per pound ThO_2 in refined as compared with the current market of $4.50 to $5.50 per d.

e current industrial uses for thorium are rather limited. Potenit is an important source of fuel for nuclear power. The mission has no procurement program for thorium as the small on hand is sufficient to cover its projected requirements for rch and development.

Foreign Activities

liveries of foreign uranium concentrates to the United States g 1961 totaled 12,915 tons of contained U_3O_8 with 8,735 tons g from Canada, 3,870 tons from South Africa, and 310 tons the Combined Development Agency contracts with Australia Portugal.

da

adian deliveries, which were about 11,310 tons of contained in 1960, totaled 8,735 tons in 1961. The reduction is a result stretch-out agreement made in November 1959 between the ission and Canada.[6] Further decreases in deliveries are exd in ensuing years. At December 31, 1961, approximately 15,200 f Canadian uranium remained to be delivered.

[6] 61–62, Annual Report to Congress (January–December 1959).

5007316

South Africa

Following discussions by Combined Development Agency (CDA)[7] representatives in Johannesburg during February and November of 1960, agreement was reached with the South African Atomic Energy Board, effective January 1, 1961, to terminate the CDA uranium purchase arrangement and replace it with separate United States-South Africa and United Kingdom-South Africa contracts.

Under the new contract, the United States will purchase 18,000 tons of U_3O_8 between January 1, 1961, and December 31, 1966—the same quantity the Commission would have bought under the CDA agreement, but at a lower price. A small quantity of South African material originally scheduled for delivery in 1961 and 1962 will be delivered in the post-1962 period but, as in the case of the superseded CDA agreement, all deliveries to the United States will be completed by December 31, 1966.

Australia and Portugal

The CDA agreement for production from Radium Hill, South Australia, expired on December 31, 1961, while the agreement for production from Rum Jungle, Australia, will expire in January 1962. Deliveries from Portugal should be completed about mid-1962. Total remaining deliveries to the Commission from Australia and Portugal after December 31, 1961, will be approximataly 200 tons of U_3O_8.

[7] A contracting agency established in 1944 as a joint United States-United Kingdom operation to insure cooperation in securing urgently needed supplies of uranium for the wartime atomic energy programs. It has continued to act on behalf of the United States and the United Kingdom with respect to the purchase of uranium ores and concentrates from non-domestic sources. Canada also is a member of the organization but, as a uranium producer with limited requirements, it has not participated in the joint United States-United Kingdom procurement activities.

Company	Location of mill	First contract signed	First U_3O_8 delivered to AEC	Present contract terminates	Maximum capacity tons of ore per day	Estimated cost of mill
1. American Metal Climax, Inc.[a]	Grand Junction, Colo.	July 10, 1950	June 1951	Dec. 31, 1966	330	$3,098,000
2. Anaconda Co.	Grants, N. Mex.	Dec. 27, 1951	Sept. 1953	Dec. 31, 1965	3,000	19,358,000
3. Cotter Corp.	Canon City, Colo.	May 23, 1957	Aug. 1958	Feb. 28, 1965	200	1,800,000
4. Dawn Mining Co.	Ford, Wash.	Aug. 8, 1956	Sept. 1957	Dec. 31, 1966	400	3,100,000
5. Fed.-Radorock-Gas Hills Partners	Fremont County, Wyo.	Apr. 10, 1959	Dec. 1959	Dec. 31, 1966	520	3,370,000
6. Globe Mining Co.	Natrona County, Wyo.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Producer	Location of mill	First contract signed	First U_3O_8 delivered to AEC	Present contract terminates	Rated capacity, tons of ore per day	Estimated cost of mill
1. American Metal Climax, Inc.[a]	Grand Junction, Colo.	July 10, 1950	June 1951	Dec. 31, 1966	330	$3,088,000
2. Anaconda Co.	Grants, N. Mex.	Dec. 27, 1951	Sept. 1953	Dec. 31, 1966	3,000	19,358,000
3. Cotter Corp.	Canon City, Colo.	May 23, 1957	Aug. 1958	Feb. 28, 1965	200	1,800,000
4. Dawn Mining Co.	Ford, Wash.	Aug. 8, 1956	Sept. 1957	Dec. 31, 1966	400	3,100,000
5. Fed.-Radorock-Gas Hills Partners	Fremont County, Wyo.	Apr. 10, 1959	Dec. 1959	Dec. 31, 1966	520	3,370,000
6. Globe Mining Co.	Natrona County, Wyo.	May 12, 1959	Feb. 1960	Dec. 31, 1966	490	3,100,000
7. Gunnison Mining Co.	Gunnison, Colo.	Nov. 15, 1956	Feb. 1958	Dec. 31, 1966	200	2,025,000
8. Homestake-Sapin Partners	Grants, N. Mex.	Apr. 23, 1957	Sept. 1958	Dec. 31, 1966	1,500	9,000,000
9. Homestake-Sapin Partners	Grants, N. Mex.[b]	Dec. 20, 1956	Apr. 1958	Dec. 31, 1966	750	5,325,000
10. Kermac Nuclear Fuels Corp.	Grants, N. Mex.	May 3, 1957	Dec. 1958	Dec. 31, 1966	3,300	16,000,000
11. Kerr-McGee Oil Industries	Shiprock, N. Mex.	Aug. 17, 1953	Jan. 1955	Dec. 31, 1966	300	3,161,000
12. Lakeview Mining Co.	Lakeview, Oreg.	Nov. 18, 1957	Feb. 1959	Nov. 30, 1963	210	2,600,000
13. Mines Development, Inc.	Edgemont, S. Dak.	Apr. 28, 1955	Aug. 1956	Mar. 31, 1962	400	1,900,000
14. Petrotomics Co.	Carbon County, Wyo.[c]	Aug. 12, 1960	----------	Dec. 31, 1966	200	1,500,000
15. Phillips Petroleum Co.	Grants, N. Mex.	Sept. 17, 1957	Aug. 1958	Dec. 31, 1966	1,725	9,500,000
16. Rare Metals Corp. of America	Tuba City, Ariz.	July 15, 1955	July 1956	Mar. 31, 1962	300	3,600,000
17. Susquehanna-Western, Inc.	Riverton, Wyo.	Dec. 4, 1957	Jan. 1959	Dec. 31, 1966	500	3,500,000
18. Susquehanna-Western, Inc.	Falls City, Tex.	July 25, 1960	June 1961	Dec. 31, 1966	200	2,000,000
19. Texas-Zinc Minerals Corp.	Mexican Hat, Utah	July 17, 1956	Nov. 1957	Dec. 31, 1966	1,000	7,000,000
20. Trace Elements Co.	Maybell, Colo.	Aug. 10, 1955	Dec. 1957	Dec. 31, 1966	300	2,208,000
21. Union Carbide Nuclear Co.	Rifle, Colo.[d]	Oct. 2, 1947	Dec. 1947	Dec. 31, 1966	1,000	8,500,000
22. Union Carbide Nuclear Co.	Uravan, Colo.[d]	Apr. 13, 1949	Mar. 1950	Dec. 31, 1966	1,000	5,000,000
23. Uranium Reduction Co.	Moab, Utah	June 1, 1955	Nov. 1956	Dec. 31, 1966	1,500	11,172,000
24. Utah Const. & Mining Co.	Fremont County, Wyo.	Nov. 14, 1956	Mar. 1958	Dec. 31, 1966	980	6,900,000
25. Vanadium Corp. of America	Durango, Colo.	Feb. 17, 1949	Aug. 1949	Dec. 31, 1966	750	813,000
26. Vitro Chemical Co.	Salt Lake City, Utah	Oct. 25, 1951	Oct. 1951	Mar. 31, 1962	600	5,500,000
27. Western Nuclear, Inc.	Jeffrey City, Wyo.	Aug. 10, 1956	Aug. 1957	Dec. 31, 1966	845	4,300,000
TOTALS					22,500	145,320,000

[a] Formerly Climax Uranium Co.

[b] Formerly owned by Homestake-New Mexico Partners and acquired by Homestake-Sapin Partners in November 1961.

[c] Under construction.

[d] New contract agreement, signed in May 1961, replaced separate contracts for these two mills.

NOTE.—The above mills are privately owned and operated, and all are licensed to buy uranium ores from producers. The U.S. Atomic Energy Commission buys the concentrate product under the terms of contracts with each mill operator.

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PRODUCTION

In the calendar year 1961, source and special nuclear materials as well as other production materials such as tritium and heavy water continued to be produced in quantities in compliance with Presidential Directives (or as required to satisfy military and peaceful needs). Reductions in unit operating costs were achieved in many areas through increased operating efficiency, and a high safety record was compiled at each production site.

Highlights of the Commission's production operations as they relate to the civilian program during calendar year 1961 include:

- A total of 800 kilocuries of purified strontium 90 was recovered from fission product wastes at Hanford, primarily for use in the SNAP (Systems for Nuclear Auxiliary Power) program.
- Two pre-1950 facilities which have been maintained on a standby basis are being reactivated at Hanford for use in recovery of strontium 90, cesium 137, and cerium 144 as the requirements for use of these radioisotopes increase.
- Reconsideration of a 1959 decision resulted in the designation of only the Savannah River and Idaho facilities as sites for receiving and chemically processing spent fuel from privately owned and other non-Commission reactors; the first three contracts for such services were signed.
- Some 74,000 cubic feet of radioactive waste materials were received from licensees for burial at Commission-owned sites; Commission activities generated an additional 3.2 million cubic feet of waste for burial.
- A series of meetings was held between Commission and United Kingdom Atomic Energy Authority personnel to exchange information on production problems and procedures.

Fission Product Production Program

The greatly increased requirement for strontium 90 and cesium 137 radioisotopes for use in Government programs has led to the recovery of these fission products from the chemical processing waste stream at the Hanford Plant, Wash. The strontium 90 is being used primarily in the Commission's SNAP program (see Nuclear Power for Space section of Part 2) and the cesium 137 is being used for fabrication into heat-energy sources and for radiation sources for a variety of applications (see Radioisotope and Radiation Development section of Part 2).

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To meet the increased demand, two facilities built at Hanford prior 1950 have been reactivated and improved processes developed for recovery of strontium 90, cesium 137, cerium 144, and promethium

During the year, about 780 kilocuries of crude strontium 90 were re-vered from the Purex head-end process. Of this amount, 70 kilo-es were further purified by ion exchange in the high-level radio-mistry cells and then shipped to Oak Ridge National Laboratory, n., for encapsulation. Approximately 710 kilocuries of strontium were further purified by solvent extraction techniques using the Hot niworks Facility which had been built in 1948 to serve as a semi-rks plant for the Redox Chemical Separations System. Later, be-being placed on a standby basis, the facility had been remodeled use with the Purex Chemical Separations System.

In addition to the strontium 90 production, 210 kilocuries of cesium were recovered from Hanford's waste tank supernatant by absorp-on Decalso (an inorganic ion exchange medium) and shipped to Ridge for isotopes development program needs.

Modifications are also being made in Hanford's standby "B-Can-—one of the three fuel element processing plants built during rtime for plutonium recovery—to handle and store crude fission duct concentrates containing multi-megacurie amounts of stron-m and promethium for decay of objectionable short-lived radioiso-es. These crude concentrates are produced in the Purex plant d-end by treating the Purex waste (raffinate) stream and are then ped to B-Canyon for further concentration and storage.

-Production Fuel Processing

In order to carry out the program of making financial settlement leased material being returned in the form of irradiated reactor the Commission had made an announcement in October 1959, its facilities at Hanford, Oak Ridge, Savannah River, S.C., and Idaho Chemical Processing Plant were prepared to negotiate con-ts to provide for chemical processing and settlement of specific ear fuel elements which had been irradiated in privately and icly owned reactors. After further study, responsibilities for re-ng all the irradiated fuels from research, test, power, and pro-on reactors, and for the design of plant modifications to permit ssing these fuels, were assigned only to the Idaho and Savannah r plants. Idaho is responsible for the receipt of all highly en-d uranium fuels, and Savannah River is responsible for all other roduction fuels. A public announcement to this effect was made

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in June 1961, by the Idaho and Savannah River Operations Offices. The reassignment was made to reduce the over-all costs and still retain sufficient capability in Commission facilities to handle the returned non-production fuel elements and meet Commission program needs.

Three contracts were executed at Idaho during 1961 for receipt of non-production reactor fuels and for settlement of the contained fuel values in accordance with existing announcements.[8] Two of these contracts are with General Electric for fuels from its Vallecitos Boiling Water Reactor and test reactor, respectively, and the other is with Westinghouse for its test reactor fuel. Although no contracts have been executed for receipt of fuels at Savannah River, negotiations between that office and several power reactor operators are currently underway.

At Savannah River, a facility for handling and storage of non-production fuels was started in June 1961. It is expected to be completed about January 1963. The plant modifications to process non-production fuels at Savannah River have not been initiated.

Disposition of Facilities

Demolition, building decontamination, and site restoration at the Destrehan Street plant in St. Louis, Mo., have been completed. As of November 30, the site and facilities were returned to the Mallinckrodt Chemical Works, thus ending Commission activity at this location.

Efforts to sell the Government-owned magnesium plant at Canaan, Conn., have been unsuccessful, as have the efforts to purchase satisfactory magnesium from commercial sources. As a result, the General Services Administration (GSA) has extended the Commission's permit to use the Canaan plant until mid-1962. The plant will continue to be operated, under contract, by the New England Lime Co.

Arrangements have been completed for the transfer of extrusion equipment from the plant at Adrian, Mich., to the Bridgeport Brass Co. plant at Ashtabula, Ohio. The action involves disposition of two Commission-owned extrusion presses and auxiliary equipment at the Adrian plant, prior to turning over the space to the purchaser of the plant from GSA. The schedule called for terminating all operations at Adrian by the end of September. One press was shut down on September 1 for dismantling, shipping, and reinstallation at Ashtabula. The other continued in operation through most of September and was sold by competitive bid on September 29. It will remain at Adrian.

[8] Published in the *Federal Register* (F.R. 1591) of December 12, 1957.

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rial in Idaho. Low-level, packaged radioactive wastes collected from Com-sion and licensee facilities in the western half of the country are buried on reservation of the National Reactor Testing Station in Idaho. Photo shows stes encased in concrete within steel drums, which were originally destined deep-sea disposal, being buried at the Idaho site. The wastes had been ected and prepared for sea disposal by a Southern California waste disposal which had its license revoked by the Commission during early 1961. The mission subsequently had the wastes transported to Idaho for land burial.

d Burial of Radioactive Wastes

Commission policy provides for permanent land-burial of low-level kaged radioactive wastes generated in privately owned operations Government-owned land (Federal or State) to assure adequate tection of public health and safety throughout the period of any ential hazard.

Commission burial grounds located at Savannah River, Idaho, Han-rd, Oak Ridge, Los Alamos and Sandia, N. Mex., the Nevada Test te, Weldon Spring, Mo., Fernald and Portsmouth, Ohio, and Pa-ah, Ky., reported a total of 3,309,000 cubic feet of radioactive waste ried during fiscal year 1961. The Oak Ridge and Idaho burial sites, ich were designated as interim locations for use by licensees in dis-sing of suitably packaged low-level solid radioactive wastes, re-rted a total of 74,400 cubic feet of such wastes buried for licensees der this Interim Burial Program and 20,600 cubic feet of waste ried for other Government agencies. The remainder of the 3,309,000 ic feet was generated by Commission and contractor activities and sisted of wastes ranging from low to high radioactivity which are ried, or stored, at the Commission-owned facility.

If, and when, the growth of the atomic energy industry shows a uirement for new low-level waste burial sites, the Commission ex-s that State governments may wish to establish and control sites the benefit and convenience of their citizens. Currently, the State

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of New York is proposing to establish a burial ground for low-level radioactive waste at its Western New York Nuclear Service Center in Cattaraugus County.

New Production Reactor

As of November 30, design of the New Production Reactor (NPR) at Hanford was estimated to be 91 percent complete, and construction was 37 percent complete.

During the late summer of 1961 a comprehensive review of the NPR construction progress and estimated cost was undertaken. As a result, it was found necessary to revise the scheduled construction completion from October 1962 to March 1963 and to increase the cost estimate from $145 million to $165 million, both of these figures excluding $7.2 million for NPR supporting facilities.

During the year, the development program in support of the NPR project progressed quite satisfactorily. The fuel element development program and construction at Hanford of the necessary production facilities for the coextrusion and fuel element finishing operations proceeded to the point of initiation of fuel element production operations.

The NPR is a convertible reactor; that is, its design includes features which will permit the addition of electric power generating facilities. If such facilities are installed, the reactor could be operated for the dual purpose of plutonium production and electric power generation or could be operated solely for the production of power. In its past session, Congress did not authorize the installation of the power generating facilities.

In September, Washington State officials announced that in the absence of federal plans for construction of NPR generating facilities the State would consider sponsoring the project, since this could be done under existing legal authority. Subsequently, the State withdrew from active participation when the Washington Public Power Supply System (WPPSS) expressed interest in building the power plant. Negotiations are currently underway between the WPPSS, the Commission, and the Bonneville Power Administration to determine if suitable arrangements can be worked out. WPPSS' plans call for financing by the sale of revenue bonds.

Gas Centrifuge Studies

The Commission in 1960 increased the United States effort on the development program of the gas centrifuge process[9] for separating

[9] See pp. 102–104, 123, 500–504, Annual Report to Congress (January–December 1960).

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topes. It is expected that the total effort will be at a level of approximately $2 to $3 million per year. The current development work includes studies in three major areas including: (1) basic research at the University of Virginia, Charlottesville, Va.; (2) centrifuge experiments by the Union Carbide Nuclear Co. at Oak Ridge, Tenn.: and (3) development of advanced gas centrifuge units by the Garrett Corp., Air Research Manufacturing Division, at Los Angeles, Calif. In addition, a special theoretical group was formed to study the gas centrifuge. The work of all contractors involved in the program is administered by the Oak Ridge Operations Office.

As noted in last year's report, the Commission's review of the gas centrifuge process indicated further development work would be necessary before the centrifuges, which up to now have been operated only as single laboratory units, could be used in a production plant. Some of the areas in which problems must be solved before a satisfactory process is possible with the current centrifuges include: increasing the reliability of the present experimental machines for continuous long-term service; development of a model satisfactory for mass production; development of a method for introduction and removal of gas when the machines are operated in a group; and a determination of the auxiliary processes, services, and instrumentation necessary for plant operations.

During April 1961, the Commission amended its regulations to extend its access permit program to classified areas of the gas centrifuge field. By late 1961, one permit had been issued—to Dow Chemical Co.

United States-United Kingdom Information Exchange

United Kingdom representatives of the Commission and the U.K. held a series of meetings during 1961 on production program subjects of mutual interest. The principal items of discussion were feed materials, chemical processing, gas centrifuge, plutonium finishing, and production reactor operating philosophy. All discussions were unclassified with the exception of those pertaining to the gas centrifuge.

FISSION PRODUCT TRANSPORTATION

Parallel to the demonstration of improved processes for the recovery and purification of large quantities of radioisotopes at the Commission's Hanford, Wash., plant, two methods have been developed for transporting hundred-kilocurie quantities of semi-pure and pure fission products in a safe manner to Oak Ridge, Tenn., where they are further purified and formed into radioactive sources.

The first method involves fixation of the radioactive material on inorganic ion exchange resin (Decalso) to permit a safe, semi-dry

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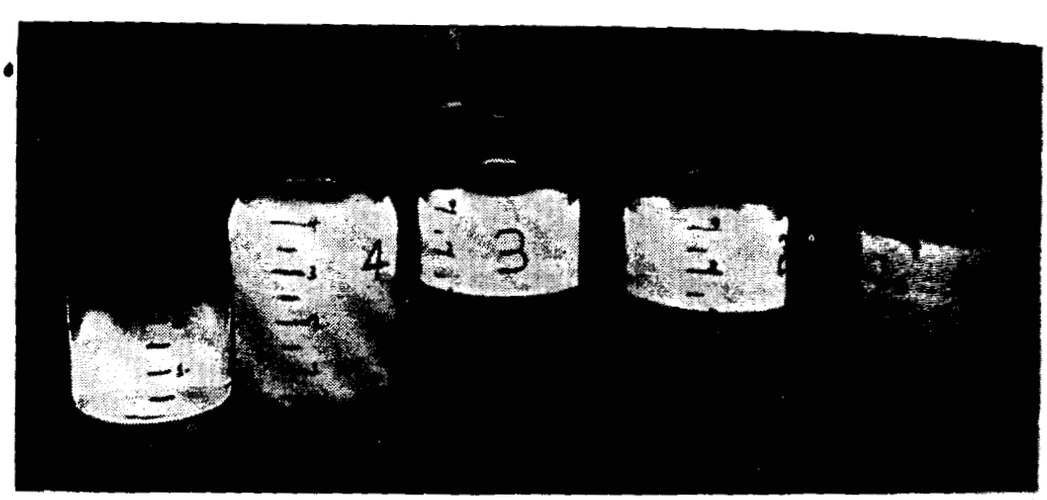
shipment in a shielded cask. The second method is to accumulate a fission product precipitate, such as strontium carbonate or a sodium rare-earth double sulfate, on a woven stainless steel wire filter within a shielded cask, the cake then being shipped as a dry solid.

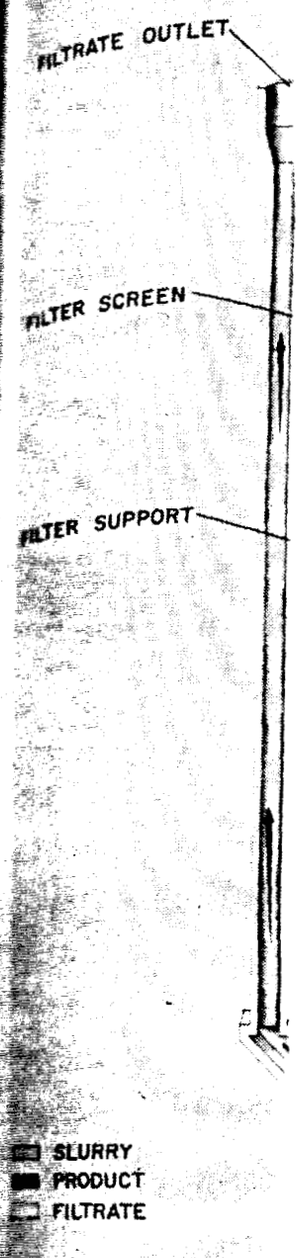
Fission product cesium is transported from Hanford to Oak Ridge in four shielded transfer casks, each of which can contain 30,000 curies of cesium 137 absorbed on 400 gallons of Decalso. Two of the cesium 137 casks are mounted on each of two specially modified gondola railroad cars which are reinforced with crash shields and roll-over supports to protect the casks. The strontium 90 is shipped in a shielded cask of high structural integrity which is within a buffer shield. The buffer shield provides protection against impact and penetration and is attached to a standard railroad flatcar or depressed center flatcar.

More than 250 kilocuries of cesium 137 and 180 kilocuries of strontium 90 have been safely transported from Washington to Tennessee by these methods. Similiar techniques and methods can be used in the future to safely transport large quantities of semi-pure or purified fission products to private processors elsewhere who are engaged in the manufacture of products containing radioactive materials.

The following five pages show the main components of the transportation system developed by General Electric Co., the Commission's contractor-operator of the Hanford plant.



Strontium Glow. Some four gallons of highly radioactive liquid strontium 90 glows in the darkness of a heavily shielded radiochemical cell at the Commission's Hanford, Wash., plant. Photographed through four feet of leaded glass shielding, the liquid was part of the first multi-kilocurie shipment of strontium 90 made from Hanford to Oak Ridge National Laboratory, Tenn., and represented the beginning of the first major program for recovery and utilization of byproducts from the Hanford plutonium production process. The strontium 90 is being recovered from the fission product waste stream. Its characteristic glow is a useful indication of its progress through the recovery process since all work on the highly radioactive element must be done remotely.



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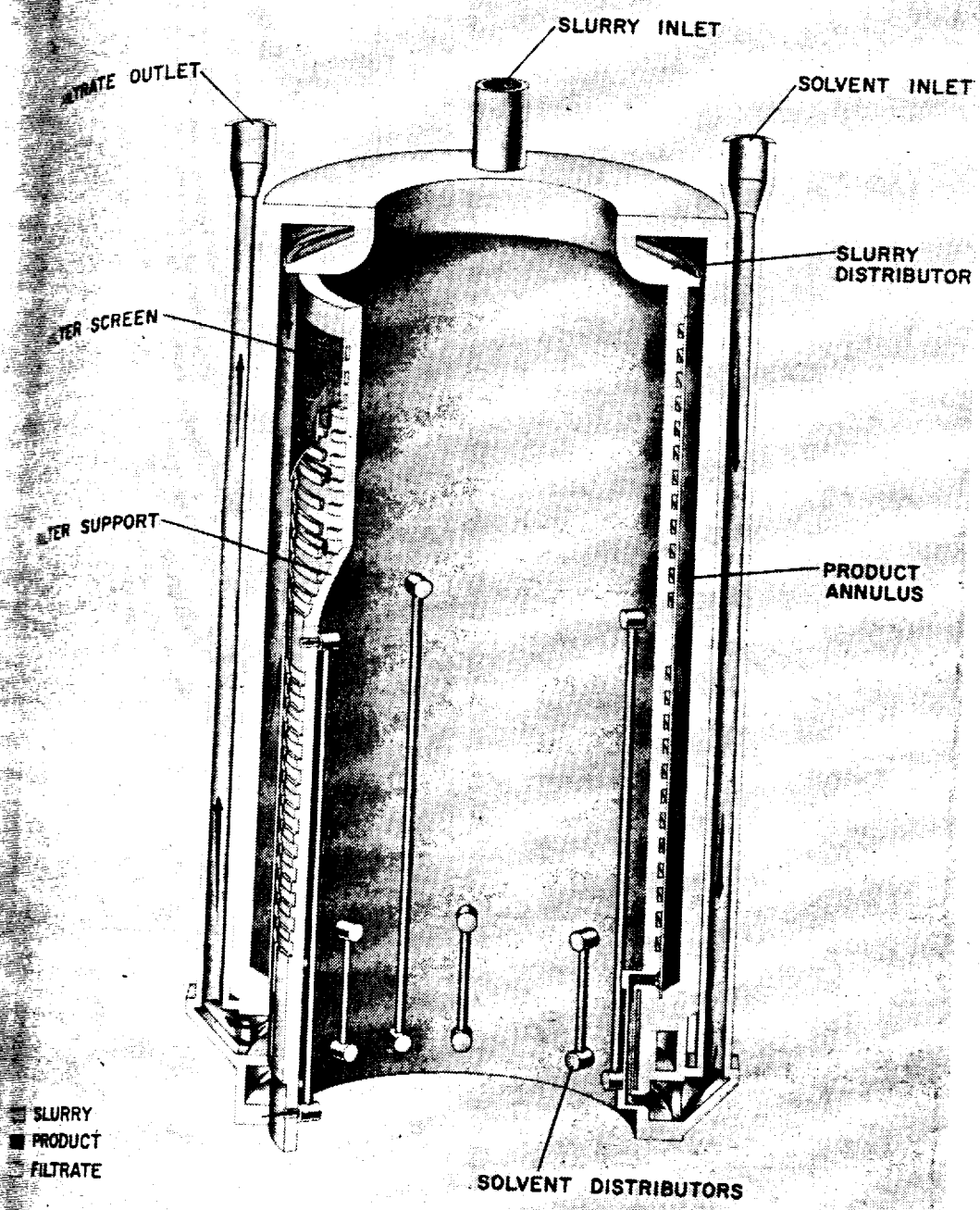

Filter-Container. Diagram of the annular product container which accumulates fission products in a thin layer on a screen. The annular container reduces temperature drop through the powder and also provides additional surface heat transfer. The annular space is ⅝-inch thick; the inside diameter is inches; the overall height is 18 inches; and 150 cubic inches of material be contained. The fission products are collected on a woven stainless steel which is supported by lands formed by a series of horizontal and vertical ves. The horizontal grooves increase the open area behind the filter screen the vertical grooves provide a path for the filtrate to flow out of the filter.

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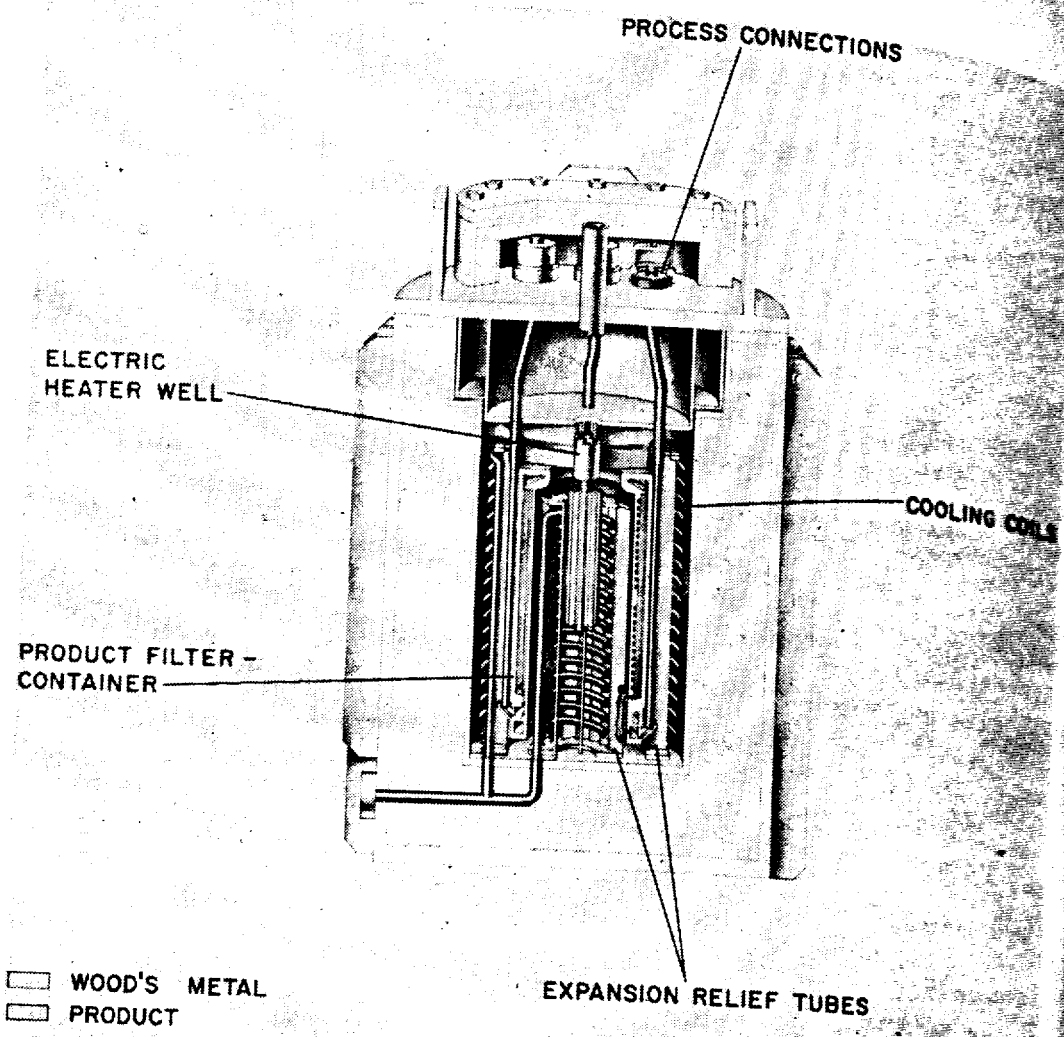

Shipping Cask. Diagram of the assembled shipping cask with the fission product container and the cask cover in place. The cask cover helps support the product container and includes the process connections for loading and unloading the product container. The cask is an externally finned, lead-shielded, cylinder with the lead shielding confined by a 1-inch thick steel outer shell and a ½-inch thick steel inner shell. The assembled cask is about 3½ feet in diameter, about 4½ feet high, and weighs 18,000 pounds.

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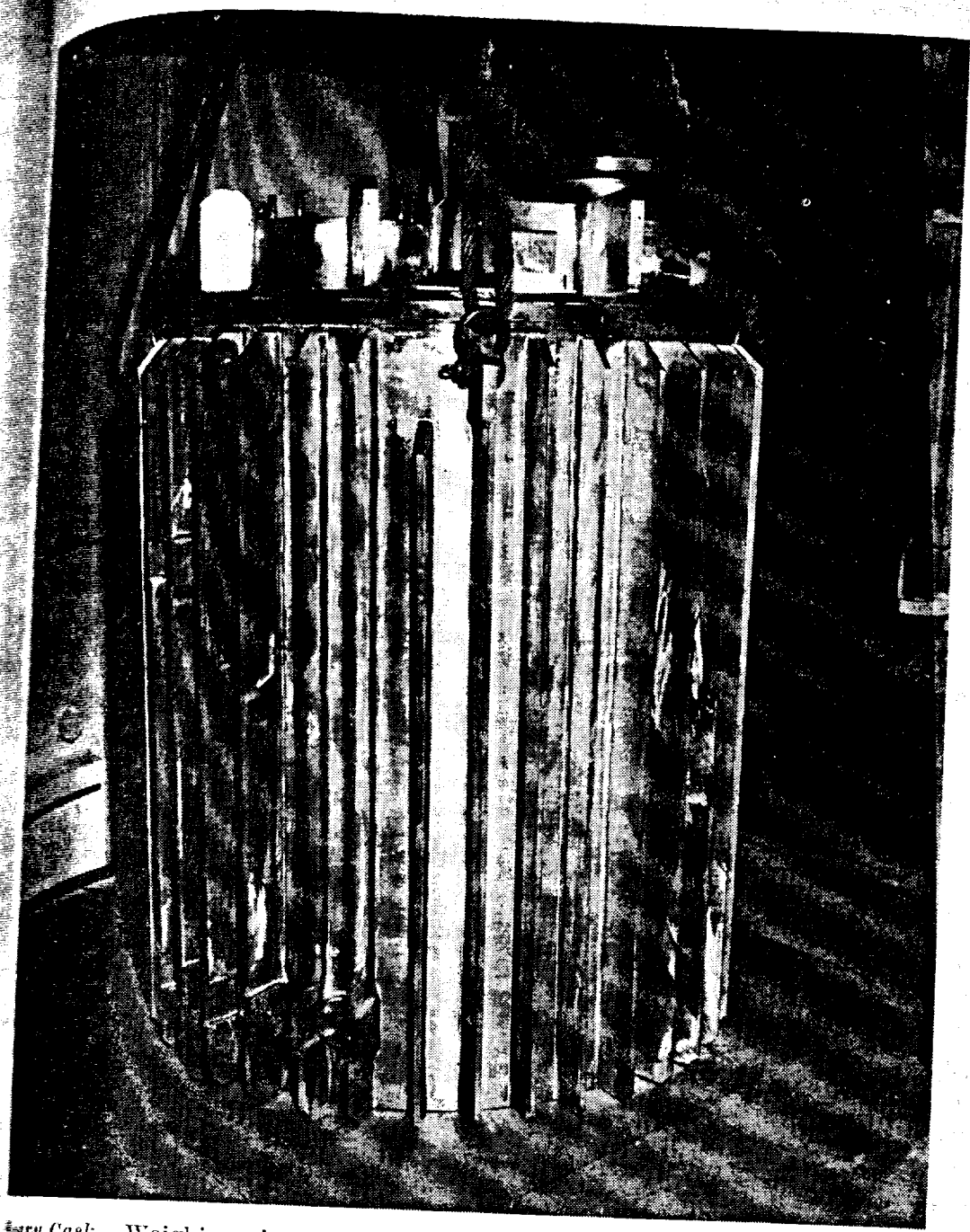

ery Cask. Weighing nine tons, the strontium 90 shipping cask can withstand force normal to the surface in excess of 50 times the force of gravity (50 G). e external fins serve a threefold purpose: (*1*) they assist heat dissipa- by spacing the cask within the cask container and by providing additional ing surface area; (*2*) they stiffen the outer steel shell; and (*3*) they assure d distribution from the container to the cask in the event of impact.

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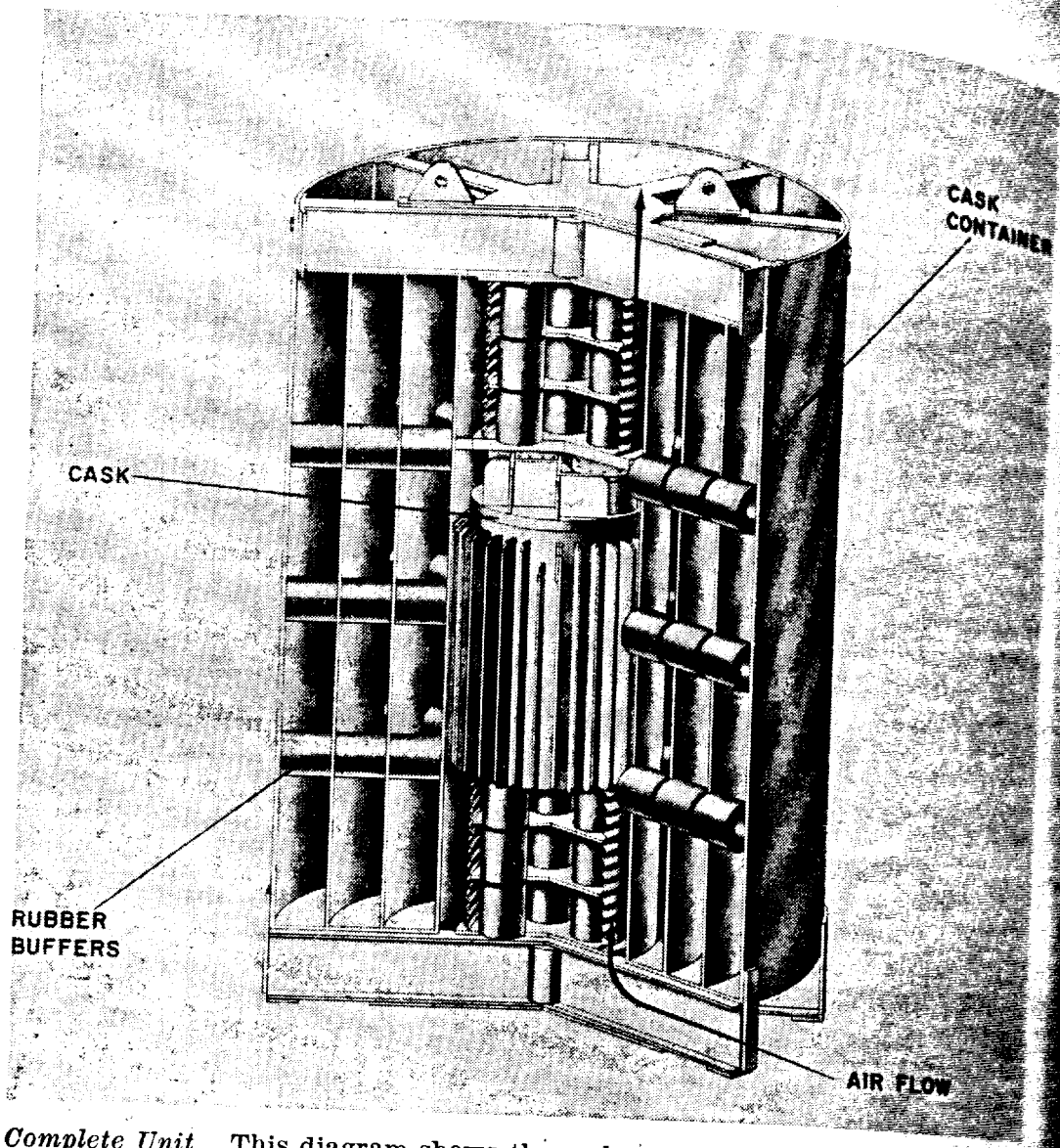
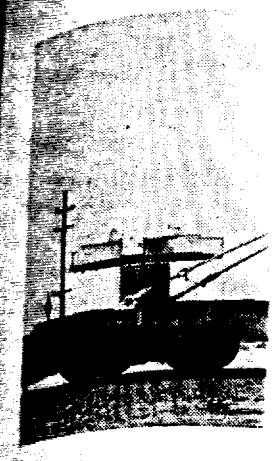
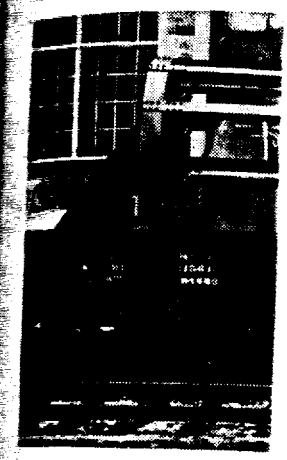


Complete Unit. This diagram shows the cask container with the cask in place. The container was designed to reduce the decelerating forces imposed on the cask, to distribute these forces over the cask surface, and to permit the air flow required for the dissipation of the heat generated by the decaying radioisotopes. The cask container consists of four concentric, steel shells which extend above the cask and below the bottom of the cask and separated by short, rubber columns. At the top and bottom of the container, heavy steel spiders are solidly attached to the outer container shell thereby making it strong against end, side, or edge impacts. The cask container is about 8 feet in diameter, 12 feet high, and weighs about 23,000 pounds without the cask in place.



Shipping Systems. for transporting str right of the car is th the outer surface; i to the car by tie ro encountered in norm tainer. *Photo belo* two casks of cesium casks, having a cap shielding and weigh



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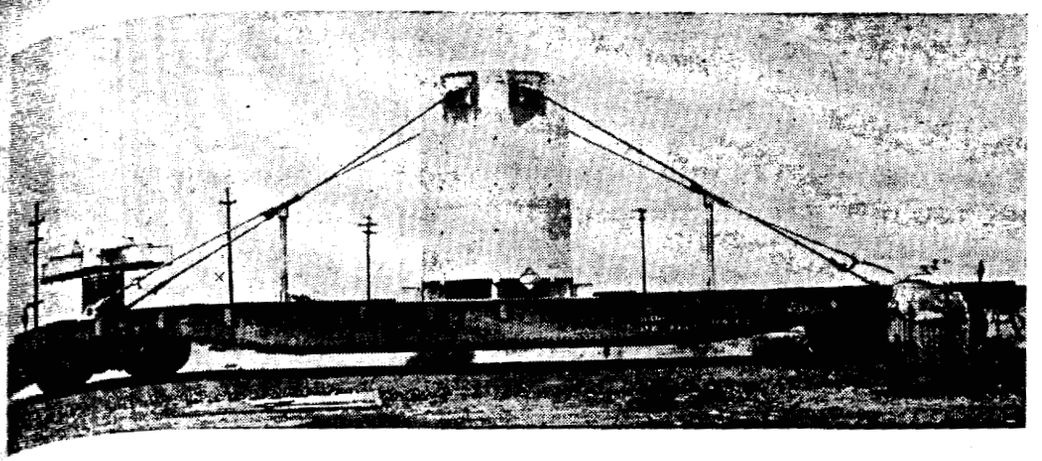
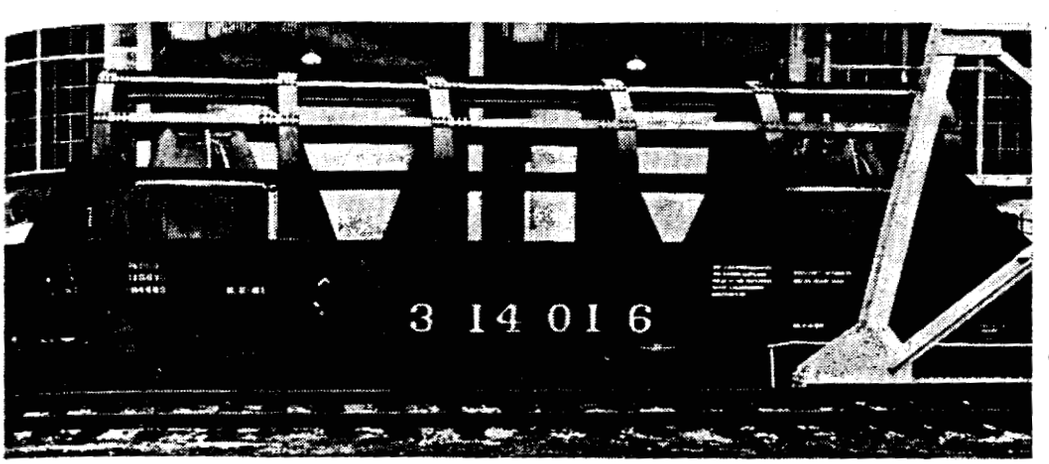


Shipping Systems. Upper photo shows one of the flatcars and components used for transporting strontium 90 from Hanford, Wash., to Oak Ridge, Tenn. At the right of the car is the cask itself covered with plastic to keep dust from lodging on the outer surface; in the center of the car is the outer container, rigidly attached to the car by tie rods which are safe for forces considerably greater than those encountered in normal railroad shipping; and on the left is the cover for the container. *Photo below* is one of the railroad gondola cars modified to protect the two casks of cesium 137 it carries. These casks are larger than the strontium 90 casks, having a capacity of 550 gallons. They are lined with 3½ inches of lead shielding and weigh 15 tons when empty.



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RADIOISOTOPE DEVELOPMENT

Highlights of the Commission's program to expand and accelerate the growing beneficial applications of radioisotopes during 1961 included:

- Byproduct material licenses at November 30, 1961 surpassed the 9,000 mark, showing an eight percent increase over the 1960 figure and marked by an eight percent increase in industrial licenses.
- Production and sales of radiosotopes reached new levels as 438,[illegible] curies of radioisotopes were distributed, and $2.7 million worth of sales were recorded.
- The largest single shipment to a licensee in Commission history of a radioisotope source—50,000 curies of cobalt 60—was made.
- Improved processes for separation of radioisotopes from fission products made the large quantities of high-activity wastes produced at the Commission's Hanford, Wash., plant a prime source of specific radionuclides for Oak Ridge National Laboratory's source fabrication work.
- The largest number of multi-kilocurie sources of radioisotopes in the Commission's history were fabricated for use in gathering scientific data, providing navigational aids, and research on pasteurization of foods.
- More new types of radioisotopes were made available in sufficient quantities for practical use in the medical and industrial fields.
- Construction was virtually completed on the High Intensity Radiation Development Laboratory at Brookhaven National Laboratory.
- The Fission Product Development Laboratory (formerly called Fission Product Pilot Plant) resumed operations; construction of the Radioisotope Process Development Laboratory is on schedule and should be completed by mid-1962.
- Radioisotopes were being used to power transmitting equipment in orbiting TRANSIT satellites and an unmanned weather station in the Arctic; fabrication was underway on a radioisotope power source for an ocean-bottom, automatic seismograph station that will be emplaced during early 1962.
- New uses continued to be developed for beneficial utilization of radioisotopes, ranging from hydroelectric turbine calibration, to oil recovery, to detection of hidden defects in growing trees.
- Studies on radiation pasteurization of foodstuffs were enhanced by the fabrication and erection of three 25,000–35,000-curie cobalt 60 research irradiators.

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PRODUCTION AND SALES

Resumption of operations in the Fission Product Development Laboratory (formerly designated as the Fission Product Pilot Plant) at Oak Ridge National Laboratory (ORNL) during August of the last year resulted in an increase in production and sales of radioisotopes. As of November 30, a total of 438,205 curies had been shipped during 1961, as compared with the 191,122 curies shipped for the same period of 1960, and the 222,703 curies shipped during the first 11 months of 1959. A parallel rise in gross income from radioisotope sales was also recorded—$2.7 million as of November 30, as compared with the $1.9 million in 1960, and the $2.0 million in 1959.

Radioisotope Distribution

As of November 30, 1961, the total amount of radioactive material distributed in 156,236 shipments from ORNL—the Commission's principal shipping point for radioisotopes—during the 15-year-old radioisotopes distribution program was 1,557,784 curies.

During the past year, there have been some unusually large increases in the amounts of certain radioisotopes shipped. For example, cobalt 60 shipments rose from 133,000 curies in 1960, to 235,298 curies during the first 11 months of 1961; and strontium 90 increased from 338 curies in 1960 to about 98,000 curies in the past year. The dramatic increase in strontium 90 is due to demand for the radioisotope as heat-electrical power sources to be used in remote weather stations. The heavy demand for cobalt 60 is attributed to the need of secondary distributors to build up inventories to meet increased demands for teletherapy and radiographic sources. An unusually large amount of carbon 14 was sold during 1961—40 curies, as compared to the average of 7 curies per year recorded previously.

As of June 1, 1961, firm orders were on hand at ORNL for 330,000 curies of cesium 137. It is estimated that 50,000 curies of this backlog had been filled by year's end, leaving a backlog of about 290,000 curies for 1962. Interestingly enough, two orders from secondary processors for over 100,000 curies each account for most of this backlog. A large share of ORNL's business includes supplying bulk quantities of radioisotopes to commercial processors who "package" the radioisotopes for re-sale.

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Record Shipment. Photo shows Oak Ridge National Laboratory employees working behind four feet of lead glass shielding and using master-slave manipulators, loading a 50,000-curie cobalt 60 source. The source, largest in the laboratory's history to be shipped to an individual licensee, is being used by the National Bureau of Standards. Photo shows one of the 12 capsules of cobalt 60 being inserted (left arm of manipulator) into the container while the other arm holds a mirror showing the inside of the container.

Record Shipment

The largest single radioisotope shipment to a licensee in the history of Oak Ridge National Laboratory was made on March 29. A shipment to the National Bureau of Standards, Washington, D.C., totaled approximately 50,000 curies of cobalt 60 and was roughly double the largest single shipment previously made from the laboratory. The previous record shipment was 22,900 curies of cobalt 60 to the Budd Co., Philadelphia, Pa., on October 4, 1960.

The National Bureau of Standards plans to use the cobalt 60 for studying effects of radiation on various materials and for fundamental research on dosimetry. The shipment, made up of 12 capsules each containing several small wafers of cobalt 60, was made in a specially-designed five-ton lead container provided by the Bureau. The container was designed with provisions for cooling water to dissipate the heat generated by the radiation sources. The Bureau transported the shipment by truck.

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Cobalt 60, one of the more widely used radioisotopes in the indus-
al and medical fields, is produced by subjecting non-radioactive
balt to bombardment by neutrons within a nuclear reactor. After
period of several months in the reactor, the highly radioactive cobalt
ready for packaging into radiation sources of various sizes.
Oak Ridge National Laboratory is the principal supplier of radio-
topes in the United States.

Isotopes Development Program

Under the isotopes development program, emphasis is being given
developing large-scale economic uses of fission product wastes
ated by nuclear reactor operation. Such utilization of these fission
oducts is important to the total nuclear energy development pro-
am in the United States because this represents the largest, and
tentially the most economical, source of radioactive energy to
isfy future demands for radiation sources and heat-power sources.
ilization of the waste may become important in waste disposal
entually and will, in any case, provide some income to offset the
tra costs of ultimate waste disposal. The principal effort in re-
arch and development is also directed toward developing means
ereby radioisotopes, and especially the radiation emanating from
lti-kilocurie radioisotope sources, can help solve long standing na-
nal problems in food distribution, control of environmental pollu-
n, and water resources development and furnish information
eded by meteorologists and seismologists. Major subdivisions of
is program include radiation pasteurization of foods, radiation
ocessing development, radioisotope technology development, radio-
tope process control and production development, and radioisotope
aining and education.

Radioisotope Production Development

proved Production

Continuing progress was made during the reporting period in re-
arch and development on new isotopes to meet the changing needs
science and technology for a wide variety of radiomaterials.
andard radioisotope preparations were improved in quality and
de more readily available, and prices were reduced.
During 1961 a successful demonstration was made by the Hanford
oratory of a high-efficiency solvent extraction process for the re-
ry and purification of strontium 90; a 5-watt and two strontium 90

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power sources of about 10 watts were completed for the U.S. Weather Bureau, Coast Guard, and Navy; most of the work was finished on a 5-watt cesium 137 power source for Lamont Geological Observatory; and methods and equipment were developed and demonstrated for the safe transportation of 100,000-curie bulk quantities of cesium 137, strontium 90, and cerium 144. In addition to these major items, fission product isolation processes were improved; large scale reactor production of iodine 125 was initiated; the previously mentioned 50,000-curie cobalt 60 source for the Bureau of Standards and three 30,000-curie cobalt 60 sources for food research irradiators were fabricated; and production techniques for cadmium 109, calcium 47, copper 67, europium 155, iodine 129, iodine 130, technetium 99, and xenon 133 were improved.

Fission Product Heat-Electrical Power Sources

Fission product sources totaling more than 750,000 curies of strontium 90, 330,000 curies of cesium 137, and 1,000,000 curies of cerium 144 were fabricated during 1961, or were in production, to meet needs for radioisotope electrical power units, heat sources, and radiation sources for a variety of applications. The first large fission product power source (strontium 90) produced in 1961 is now supplying power for an unmanned weather station transmitting meteorological data from Canada's remote Axel Heiberg Island. The source was fabricated at Oak Ridge National Laboratory, using radioisotopes that had been recovered at Hanford from fission product wastes. The strontium 90 is a byproduct of the chemical processing of used reactor fuel elements. The solution was reduced to strontium titanate and then pressed into eleven pellets of about 1,600 curies each. After sintering, the pellets were placed in a capsule, welded, and checked for leak tightness. The entire operation was performed at ORNL's Fission Product Development Laboratory behind heavily shielded cells because of the high levels of radioactivity. The 17,500-curie source is 1,500 times larger than any strontium 90 source previously prepared at ORNL.

Two additional, and still larger, sources were prepared and shipped from the Oak Ridge National Laboratory to The Martin Co. in Baltimore for insertion in thermoelectric generators. These sources contained 40,000 curies. The first will produce 250 thermal watts of heat and 12 watts of electricity for use in powering a weather data telemetry unit. In this case, strontium carbonate was converted to 1,250 grams of strontium titanate in the Oak Ridge National Laboratory's Fission Product Development Laboratory. The titanate was then con-

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verted into 28 ceramic pellets, each having about 1,400 curies of activity equivalent to about 9 thermal watts. Seven pellets were placed in each of the four Hastelloy C capsules which were then welded remotely. Krypton 85 was utilized in checking the welded capsules for leak tightness. The 17,500 curie strontium 90 titanate source for the watt weather station unit and two similar 40,000-curie sources for the Navy (SNAP 7C) and Coast Guard (SNAP 7A) were fabricated at ORNL. The fabrication procedure for these strontium 90 titanate sources was developed cooperatively by ORNL and The Martin Co. The power units for the sources and the source capsules were constructed by The Martin Co. under Commission contract.

Delivery of 100-kilocurie quantities of pure strontium 90 carbonate by The Martin Co. facility at Quehanna, Pa., will begin by early 1962. Martin will fabricate and assemble two 60-watt strontium 90 titanate power generators (SNAP 7B and SNAP 7D) for the U.S. Navy and the U.S. Coast Guard utilizing a total of approximately 600 kilograms.

Fabrication of a 28,000-curie cesium 137 polyglass source for an ocean floor seismograph power unit to be tested by Lamont Geological Observatory was scheduled for completion by Oak Ridge National Laboratory in December 1961. The cesium 137 power units were developed by the Royal Research Corp. under Commission contract.

Processes for isolation of large quantities of specific fission products from reactor fuel reprocessing effluents were demonstrated at Hanford. A one-megacurie quantity of strontium 90 was isolated from the Purex chemical reprocessing waste stream and an ion-exchange process for purification of strontium 90 and promethium 147 was demonstrated. At ORNL, improved cerium 144 and technetium 99 purification processes were developed. ORNL is now purifying technetium 99, an element which does not exist in nature, in kilogram quantities as the pure metal or ammonium pertechnetate. This rare element has excited interest because of its potential as a super-conductor and corrosion inhibitor. Recovery of cesium 137 from aged wastes at Hanford has assured, for ORNL fabrication work, large quantities of a pure product, that has a low content of cesium 134 which is a more penetrating gamma emitter than cesium 137 and therefore introduces shielding problems.

An outstanding accomplishment has been the successful demonstration of a new solvent extraction process, developed at ORNL, for the isolation and purification of strontium 90, cerium 144, and the other rare earths. The first test run at Hanford of the process for final purification of strontium 90 resulted in production of 200,000 curies of pure strontium 90. The product was isolated by a precipitation process in the Hanford Purex plant from fission product wastes that had been aged about one year to permit the decay of strontium 89.

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Neutron-Capture Radioisotopes

Continued improvements in processing procedures, better production methods, and use of enriched stable isotopes as targets have resulted in greater variety and lower cost of radioisotopes produced by neutron irradiation of target materials in reactors. New isotopes of particular interest, which were made generally available during 1961, include calcium 47 and iodine 125.

Calcium 47 is a radioisotope that is of importance in medical diagnosis, particularly for diagnostic and research work related to metastatic bone cancer.[10] Its use as a tracer has made possible the location of metastatic cancer of the bone several months before it could be recognized by conventional methods such as X-ray photography. Calcium 47 is produced by neutron bombardment of enriched calcium 46 which has been separated electromagnetically from other calcium isotopes at ORNL. During the past year, the gain in quality by reducing the amount of undesired Ca^{45} from a ratio of Ca^{47}/Ca^{45} :: 10/1 to 25/1 is most significant.

Iodine 125 [11] has a relatively long life of 60 days and a low integral dose when deposited in body tissues because of the absence of beta radiation. In medical diagnosis it shows great promise for thyroid gland studies, blood plasma volume determination, and brain tumor localization. Iodine 125 is produced by reactor irradiation of xenon of natural isotopic composition at ORNL. Studies are in progress on the use of enriched xenon target material and continuous production processes to make this valuable radioisotope even more readily available.

Safety Criteria for Sealed Sources

The predominant industrial use of radioisotopes in this country is as sealed sources. Since the number and diversity of uses of sealed radioisotope sources, in new and varied designs, are expected to expand continually, the Commission has undertaken a research and development program to develop standard safety criteria for a wide range of sealed sources.

Source performance is being evaluated by Battelle Memorial Institute under a variety of conditions—thermal, mechanical, chemical, radiation and pneumatic—which might be encountered under both normal and abnormal conditions of use. The information generated by this program will help to accelerate the peaceful uses of radioiso-

[10] See p. 16, "Atomic Energy Research in the Life and Physical Sciences—1960".

[11] "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Management—1961".

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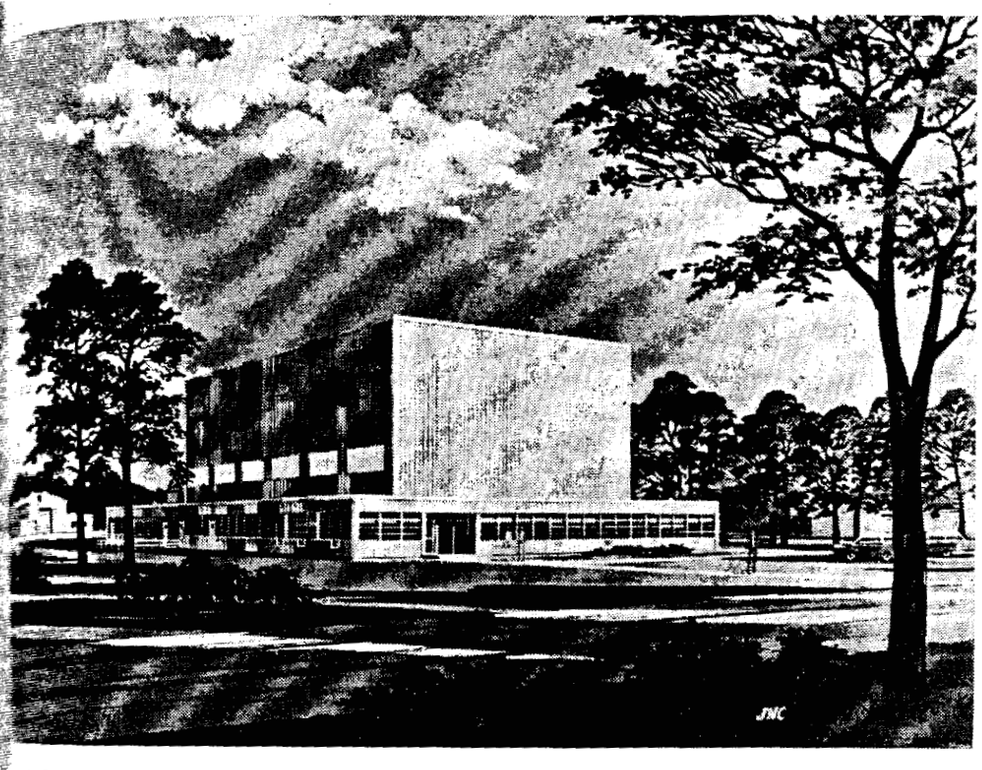
Industrial Process Radiation Development

The use of high-intensity ionizing radiation as a processing agent represents an important potential for the production of new and unique materials as well as the improvement of existing products. The Commission's program in this area is directed toward improving existing radiation technology. During 1961 appreciable progress has been made in the following areas: basic studies of pertinent reaction mechanisms and means of their control; design of high-intensity radiation sources of various types to support research on radiation processing with emphasis on efficiency and safety; and studies of radiation process feasibility.



Laboratory. Artist's sketch of the High Intensity Radiation Development laboratory now under construction at the Commission's Brookhaven National laboratory. The laboratory is expected to be completed during the early part of 1962. The laboratory will be used to obtain engineering data on a variety of radiation sources in the million-curie range; in the development of more efficient techniques for handling large-scale radiation sources; and in training scientists and engineers in the uses of such radiation sources for research purposes and industrial applications.

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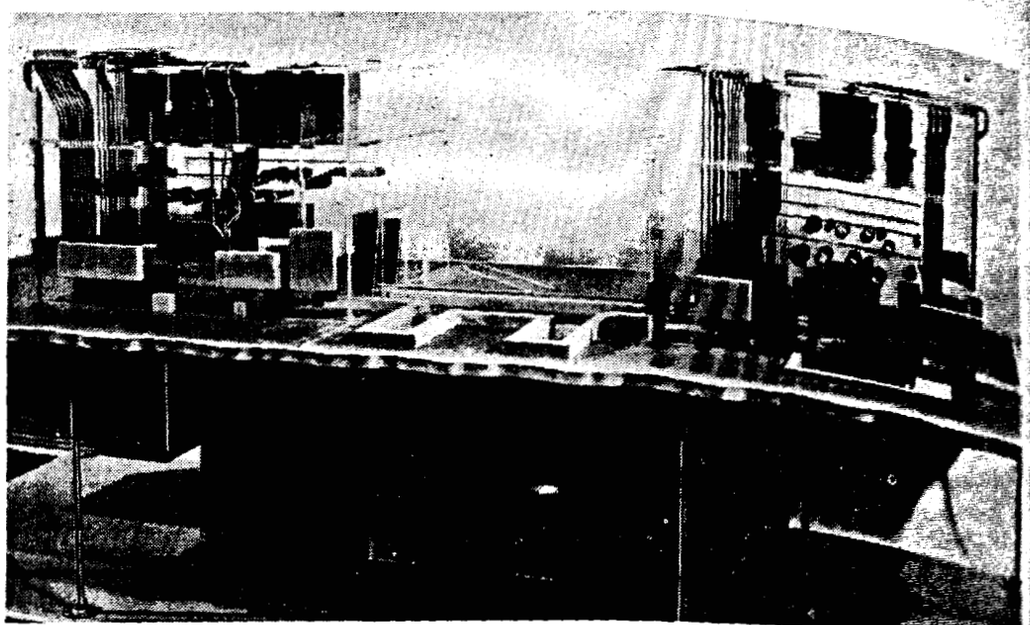

Unique Cells. The High Intensity Radiation Development Laboratory will utilize two unique cells. The model shows the Preparation Cell (on *right*) where various types of sources will be prepared for experimental use. The cell can also be used for irradiation experiments or any other types of experiments requiring remote handling. On the *left*, is the Irradiation Cell which includes lead-glass shielding windows, remote control manipulators, and periscopes. Here, materials will be exposed to the radiation sources for high-level irradiation studies and evaluation of various geometric arrangements of sources. Between the two cells is a 45-foot long canal, 16 feet deep, and with a 20-foot deep storage pit in the center. The canal will serve for transportation of high intensity sources between the two cells, the water serving as a shield during the transfer process. Wood blocks on the model indicate control panels.

Radiation Engineering

In order to generate the engineering design and operational knowledge essential to expansion of the potentials of process radiation, the Commission is constructing a High Intensity Radiation Development Laboratory (HIRDL) at Brookhaven National Laboratory. Construction began November 28, 1960, with completion scheduled for the early part of 1962. This facility will provide a unique concentration of personnel and equipment for the advancement of technology in the design and standardization of high-intensity radiation sources; in the dosimetry and radiation safety of large-scale irradiators; and in the design of irradiation facilities.

Much Commission-sponsored research on radiation process technology is adaptable to both radioisotope and electron-beam processing. For example, during the past year, radiation graft polymerization to form unique plastic materials—a process developed previously in Commission laboratories using radioisotopes—has become an important

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ustrial technique utilizing machine radiation. These products ve been very useful in the space program since they are able to with- nd extremes of temperature.

In addition to Commission activities, commercially sponsored ap- ed radiation research has continued with the development of new terials with unique properties. These include: improved wire in- ation, new plastic food wrapping material, battery separator mem- nes, sterilized medical supplies, water desalination membranes, and ymer film with improved dye characteristics.

ocess Research

A variety of Commission-sponsored investigations are contributing process radiation technology. In all, the Commission had 14 con- cts in effect during 1961 in this area.

Continued research at Radiation Applications, Inc., on methods of ering the radiation level required to vulcanize monomer-polymer xtures may reduce the present production cost of such materials as radiation-polymerized polyethelene wire insulation now used in ded missiles.

Studies of the effects of additives also by Radiation Applications, increasing the yields of radiation graft polymerization reactions y result in reduced production costs of new plastic films. These s exhibit unique and valuable properties but are at present costly produce.

The effects of ionizing radiation on increasing the sedimentation e of sewage are being investigated by Universal Match Corp. Suc- sful development of this technique could appreciably increase the acity of existing sewage plants, or reduce the size of proposed age treatment basins.

Continuing studies of the nature of the mechanisms of various radi- n-induced reactions related to radiation processes have been pro- ing valuable technical data which contributes directly to better erstanding of key reaction mechanisms. This work is being done William H. Johnston Laboratories.

Research on the influence of molecular structure on graft copoly- ization reactions by Battelle Memorial Institute is providing wledge that will eventually allow chemists, using radiation, to ide "tailor made" unique plastic materials.

Creation of new and unique textile materials having a wide range aluable properties such as mildew resistance, water proofing, and ch resistance is a promising use of radiation being investigated at th Carolina State College.

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Continued research on the radiation synthesis of metals is establishing the technical feasibility of producing such valuable ultra pure metals as silicon for semiconductor use. This work is being done by Technical Research Group, Inc.

Continuing progress in source design criteria and handling techniques has been made with regard to large (thousands to millions of curies) cobalt 60 and cesium 137 sources. Effort has also been expended on safety aspects of the entire process radiation program.

New experimental ceramic beta sources utilizing strontium 90, promethium 147, and cerium 144 have been fabricated by Radiation Applications, Inc., and are undergoing tests at Long Island City, N.Y.

Isotopes Technology Development

A broad spectrum of radioisotope potentialties are being explored under the Commission's isotope technology development activities. Principal program areas include: isotopic power systems, safety testing of radioisotopic materials, activation analysis, low-level tracer, process control, isotope measurement systems, radiometric analysis, radiation absorption analysis, radioisotope fluid dynamics techniques, ionization technology, and non-destructive testing. During the past year, emphasis has been placed on a search for new principles of radioisotope applications with broad scientific and engineering implications.[12] In all, some 70 research and development projects are advancing technology in these areas. The work is being done at research centers, universities, industrial organizations and other government agencies. In 1960, there were 64 such technical projects.

The most striking example of isotope technology development during 1961 was the successful demonstration of the feasibility of isotopic power as a reliable source of electric power to meet unique requirements for exploration of space. The use of isotopic power in the TRANSIT satellites is discussed under the SNAP program in the Military and Space Applications section of this report. Of equal importance is the use of radioisotopic devices for telemetering data from remote regions of the world and from the ocean floor.

Particular attention is also being paid to isotope technology having potential benefits in meteorological data collection, environmental pollution control, assurance of food and drug purity, crime detection, and water resource development. In these public benefit phases of isotope development, some emphasis is given to engineering of isotopic devices and to production of test equipment for specific purposes. Commission research in these areas is of assistance to public, state and municipal organizations.

[12] See Appendix 4.

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Station Installation. T
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Automatic Weather

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Advanced research has also included investigation of the possibilities for applications of neutrons in gaging and nondestructive testing and improvements in neutron production and image formation. Prompt radiation emitted in neutron capture processes presents gaging potentialities not realized by the usual radioisotope decay radiations.

Installation. The unmanned weather station was installed on bleak Heiberg Island in the Canadian Northwest Territories during August 1961. shows the strontium 90 source being lowered into its hole. In the background (center) are the radio transmitters which will fit atop the power source. The unit is similar to the one shown on page 68.) The station will automatically collect and transmit weather data at three-hour intervals. The entire unit designed to operate maintenance-free for several years without refueling.

Automatic Weather Station

In August 1961, the world's first isotope-powered automatic weather station was placed in service by the U.S. Weather Bureau in cooperation with the Canadian Government. It is located on Axel Heiberg Island, a remote and uninhabited area in the Canadian Northwest Territories. The unattended station measures wind speed, wind direction, temperature, and barometric pressure and routinely transmits the collected data every three hours to manned weather stations located in Canada and the United States.

Power for the station is provided by a 5-watt strontium 90-fueled thermoelectric generator. The 112 thermal watts of heat from the radioactive decay of the strontium 90 is converted directly to elec-

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tricity through thermocouples. Excess heat not converted to electricity keeps the station's electronic components warm, thus enhancing their operating reliability under the severe Arctic weather. The isotopic source is an insoluble and biologically inert chemical form of strontium 90, incorporated in a ceramic-type compound, strontium titanate.[13] This is securely sealed within a corrosion resistant capsule and a heavy lead shield to assure safety.

Particular attention was devoted in the design and fabrication of the automatic weather station to long-lived reliability commensurate with the isotopic power supply. The entire station has been designed to operate two years or more without maintenance, although the strontium 90 thermoelectric generator should provide usable power for up to ten years.

Underwater Seismograph Station

The need for more accurate information on earthquakes, leading to the possibility of predicting destructive shocks, is well recognized. Since recording of earth tremor frequency and distribution is presently limited by the fact that three-quarters of the world's surface is under water, a seismograph station that could be located anywhere on the ocean floor and automatically transmit its recorded data would add immeasurably to knowledge about earth movement.

In cooperation with Columbia University's Lamont Geological Observatory, the Commission has designed and started construction of such an isotope-powered seismograph station at Royal Research Corp. A thermoelectric generator which directly converts the heat produced by the radioactive decay of cesium 137 into five watts of electricity will be used to power an experimental station to be placed on the floor of the Atlantic Ocean early in 1962.

The cesium 137 thermoelectric generator will have a cylindrical shape, 30 inches high by 13 inches in diameter, and weighs slightly over 400 pounds. The cesium 137, which is contained in an insoluble and unreactive form called cesium polyglass (a calcium cesium aluminum borosilicate), is securely packaged in a corrosion-resistant capsule and shielded by depleted uranium. Even if the capsule were broken, the cesium polyglass would resist the corrosive action of sea water for many years. The entire generator is protected by a two-inch-thick aluminum alloy shell that will permit operation at ocean depths of 36,000 feet.

[13] See pp. 188–190, Annual Report to the Congress (January–December 1960).

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Water Resources

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ter Resources

Radioisotope tracer techniques offer a unique means for obtaining ter understanding of the underground flow of water and ground rvoir recharge. Assurance of adequate water for growing public industrial needs is of equal interest to technologically advanced ions as well as to arid regions of the world. The Commission cooperating with the U.S. Geological Survey and other agencies applying radioisotope capabilities to this broad area of potential efit.

A survey has been completed on applications of tracer and radio-clear techniques to water resources problems. The survey has cov-d the use of radionuclear techniques in the chemical, physical and logical analysis of water, in the tracing of surface and subsurface ter, in the treatment of domestic and industrial water supplies, trac-of wastes and sediments, and in movement of moisture in soil. cial attention has been given to the use of tritium, krypton 85 and benium 106 for tracing water and to the use of neutron absorption neutron activation of stable isotope tracers in water. This survey vides guidelines for future development.

In an experiment at Lake McMillan reservoir, N. Mex., 150 curies ritiated water were thoroughly mixed in the shallow reservoir and wed to seep into its underground storage system. By using the tope dilution technique and sampling downstream, where lake water erges from springs and flows back into the Pecos River, an ac-ate estimate can be made of the volume of water held in storage ny time.

bine Calibration

Radiotracers may be used to help conserve water through a recently loped method of calibrating the flow through turbines in hydro-ric power plants. This method uses only a few millicuries of gold nd offers a practical, inexpensive approach to turbine calibration pplying the total count method for accurate flow rate determina-. Standard methods such as the velocity-flow and salt-dilution niques are both expensive and time-consuming. Only a cupful of ion containing radiogold tracer is required as contrasted with al carloads of salt needed for the salt dilution method. The pre-is greater than one percent. Broader use of isotopic turbine will contribute to water conservation by increasing the efficiency droelectric power production.

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Deep-water Isotopic Current Analyzer

Accurate determinations of slow moving currents in bays and estuaries are particularly important to the control of water pollution and silt formation. A device incorporating a radioisotope technique which is capable of measuring extremely slow water movements has been developed and will be field-tested by the Chesapeake Bay Institute of Johns Hopkins University early next year. The instrument basically consists of a neutron source and a cannister of stable materials, surrounded by a 30-inch-diameter ring of radiation detectors. The neutrons, striking the stable materials, generate very short-lived radioisotopes which are then released into the water. The time it takes for the radioactivity to reach a particular radiation detector provides an accurate determination of the rate and direction of the water currents. Radioactive dysprosium 165, for example, has a half life of only 75 seconds, yet can measure the flow of currents ranging between 1 and 10 cm/sec.

Radiotracers in Secondary Recovery of Oil

Commission field and laboratory studies are continuing, in conjunction with the U.S. Bureau of Mines, to optimize radioisotope tracer techniques as aids in recovering billions of barrels of oil known to be left in old reservoirs. Simultaneous field tests are being carried out in the states of Oklahoma, West Virginia, and Pennsylvania to evaluate new tracer techniques in three major secondary recovery processes. In each case, selected radiotracers are being passed between injection and production wells to yield information on the underground fluid dynamics involved in the processes.

Neutron Activation Analysis

When bombarded with neutrons, most elements become radioactive and emit identifying radiations. An important research and development aim is to make neutron activation a more rapid, economical, and convenient analytical tool. To further this purpose, the coupling of scintillation spectrometer data to digital computers is being investigated. The system will make practicable the automatic analysis of large numbers of samples for such things as soil nutrient, water pollutant, drug purity, and geochemical investigations. An automated system for the activation, selection, and gamma ray spectrographic analysis of 100-sample lots has been built and is now undergoing tests at Texas A&M University. If successful, this will represent a major step forward in broadening neutron activation technology.

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technical feasibility of an activation principle in detecting explosives, as in airplane luggage, by neutron beam examina- has been demonstrated by work done for the Commission at lic University, Washington, D.C. Practical application will d on logistic and economic factors now being investigated. investigation is being carried out in cooperation with the Fed- Aviation Agency.

illating Ion Exchange Resins

xpensive and sensitive instruments that can detect and measure small concentrations of radioisotopes in water supplies, and in nts from industrial processes and waste disposal plants, are d in order to apply tracer methods in water conservation and tion control. Efforts are proceeding at Tracerlab, Inc., on the lopment of scintillating ion exchange resins for this purpose. exchange resins can remove tracer quantities of radioisotope- d substances from liquids, while scintillating materials can de- the radiation of minute amounts of radioisotopes, thus permitting sensitive qualitative and quantitative determinations necessary research in these areas.

oisotope Mass Flow Meter

rices currently used for metering the pipeline flow of foodstuffs processed involve contact with the food. Thus, devices such as type meters, require a sustained effort to maintain sanitation and someness of the product. A new nuclear radiation gauging ique having a unique capability for performing such flow meas- nts without moving parts touching the foodstuff has been de- d by Armour Research Foundation and successfully demon- d with milk as the measured medium. The U.S. Air Force has d that the system also has promise for metering cryogenic rocket

ation of Defects in Logs and Trees

lumbering industry would be benefited by improved techniques y and accurate detection of defects in living trees, construction s, and related wood products. A device incorporating a radio- e source which measures the density of wood would be valuable grading of logs for various uses and revealing defects due to ded metallic objects, rotten projecting limb stubs, included bark, calized decay. A technique based on the backscatter effect of

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radioisotopic gamma rays, as from cesium 137, now under development by the Research Triangle Institute in North Carolina appears promising for this purpose.

Radiation Pasteurization of Food

The Commission's program on radiation pasteurization of food is aimed at developing the technology necessary to demonstrate whether it is technically feasible and practical to use relatively low doses of radiation to extend the refrigerated shelf life of perishable foods. Any commercial application of low-dose radiation pasteurization of food, after the demonstration of technical feasibility, would be the responsibility of private industry.

The low-dose radiation pasteurization method involves irradiation with less than one million rad as contrasted with the three to five million rad high-dose irradiation [14] necessary for long-term preservation without refrigeration. The low-dose method promises to be the most immediately useful civilian application of ionizing radiation for food processing purposes since it could aid in better food distribution by making foodstuffs available in as near fresh condition as possible and minimizing processing effects on quality. It could also have economic value by making possible the distribution of near-fresh perishable foods in distant markets.

Programmatic planning studies by Stanford Research Institute and the Massachusetts Institute of Technology have been completed. Specific products have been selected for development, and a coordinated research and development program has been outlined. Studies necessary to demonstrate wholesomeness and to meet Commission and Food and Drug Administration requirements for public health and safety of marketable items have been defined. Research irradiators have been completed, and conceptual design studies of other facilities required have been made at the Brookhaven National Laboratory (BNL).

Irradiators

Three research food irradiators have been constructed and installed at the University of California (Davis), University of Washington, and Massachusetts Institute of Technology (MIT) to support research at these sites. Employing 25,000 to 35,000 curies of cobalt 60,

[14] Research on high-dose radiation sterilization of foods for non-refrigerated preservation is being conducted by the U.S. Army's Quartermaster Corps. The Army and Commission programs are complementary.

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units were developed specifically to provide on-the-spot irradia-
services to the research organizations. The first irradiator was
by Brookhaven and installed at Cambridge, Mass., during 1961
by both MIT and the U.S. Department of Interior Techno-
Laboratory at Gloucester, Mass. The two West Coast irradia-
also installed this year, were built by Process Equipment Corp.,
NL specifications.

ies have been initiated to design transportable units which
be utilized at the harvest site or packing house in the case of
or close to existing processing plants in the case of fish. These
with a semi-production capacity, would be capable of demon-
the practical feasibility of radiation processing and at the
me aid in the determination of the economics involved.

e central irradiation facilities located in areas where large
ies of specific types of foodstuffs are harvested regularly and to
the foods would be transported, and specialized in-plant facili-
oth capable of commercial production, are currently in the con-
l design stages.

mental Research

University of California at its Davis campus is conducting re-
on selected fruit products, relating radiation to the various
arvest techniques in terms of shelf life extension, as well as
such areas as food chemistry, microbiology, and patho-
y.

s and haddock are being investigated through coordinated
s at the Massachusetts Institute of Technology and the De-
t of Interior's Technological Laboratory at Gloucester, Mass.
ilar coordinated research effort exists at the University of
gton and U.S. Department of the Interior Technological Lab-
in Seattle, Wash. Dungeness crab and flounder are the spe-
g investigated.

g Feasibility

arket feasibility study conducted for the Commission by the
Department of the Interior Bureau of Commercial Fisheries
d a strong willingness by the fish industry to utilize the radia-
ess. The study concluded that the process could revitalize
g industry by expanding the fresh fish market to inland
sently inaccessible because of the short shelf life of the fresh

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Packaging

A study is being conducted for the Commission by the Continental Can Co. to review data on packaging technology. The study will recommend the type of a research and development program necessary to meet the packaging requirements of the low dose pasteurization program.

Wholesomeness

The Commission, during 1960, initiated studies related to the determination of wholesomeness and safety of radiation processed foods. The studies will ascertain the nutritional and microbiological wholesomeness, and the health aspects of perishable foods which have been irradiated by gamma radiation sufficiently to preserve them or to extend their life in storage. Results of this program are not yet far enough along for evaluation.

Radioisotopes Training and Education

The Commission's radioisotope technology training activities are intended to help incorporate appropriate background into the education of scientists, engineers, skilled workers, and technicians, and to inform the public concerning the benefits and safety of radioisotope applications. Approaches include assistance to colleges and universities in obtaining equipment to incorporate radioisotope training in their physical sciences and engineering curricula, faculty training, course and training aid development, and production of films.

(Activities carried on during 1961 in this area are described in the Education and Training Section, Part 3 of this report.)

PLOWSHARE PROGRAM

The Commission's Plowshare program is directed toward demonstrating that nuclear explosives can be used for a variety of peaceful industrial, scientific, and civilian uses such as excavation projects, the tapping of water and mineral resources, and possible heat reservoirs. The program was given separate divisional status (Division of Peaceful Nuclear Explosives) within the Commission organization during 1961. Major activities during the year included:

- The first nuclear detonation experiment, Project Gnome, was successfully conducted in New Mexico on December 10.

- Planning and s
large-scale excava
- Data obtained
conducted by th
(Livermore) prov
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explosives to peac
- Laboratory effo
areas of explosion
struction of canals
and roads; and (
reactions, oil recov
ion, and isotope

Gnome Location. Sty
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shows the location of
evacuated as an adde
Plowshare program is
nuclear explosives in

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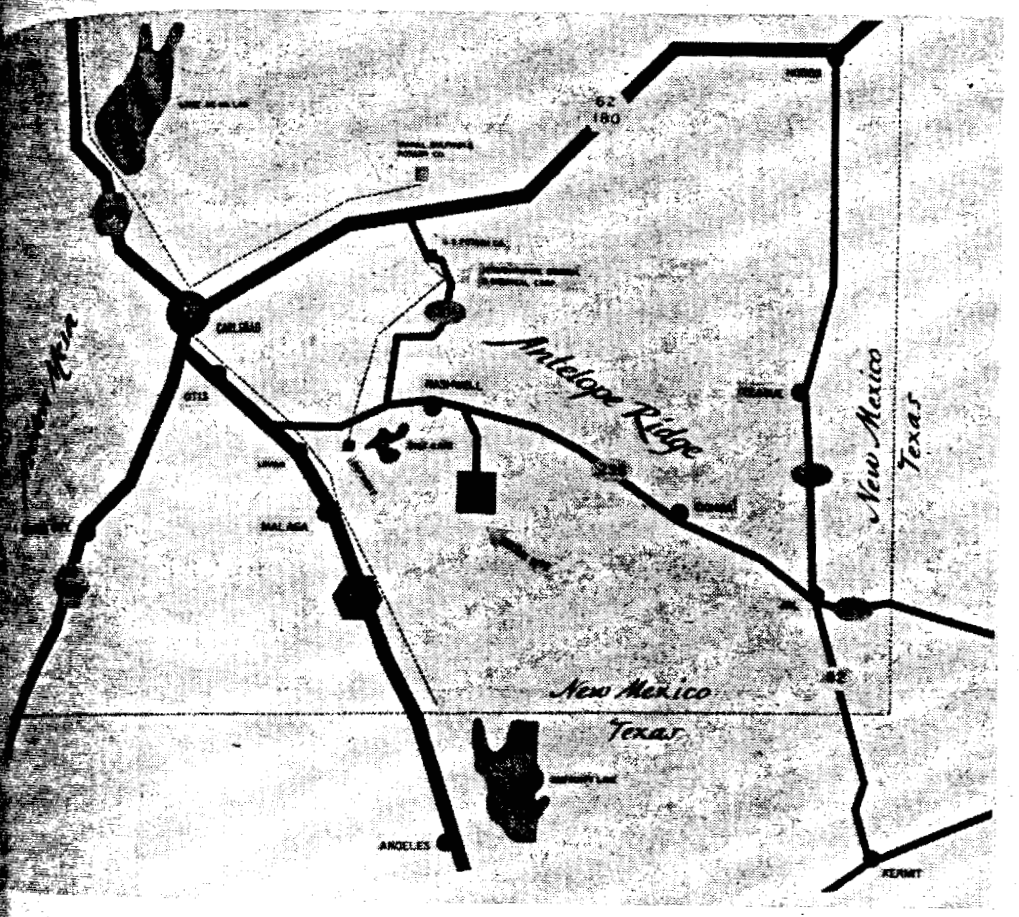
Planning and scientific environmental investigation for a proposed ...e-scale excavation (Project Chariot) in Alaska was continued.

Data obtained from chemical explosive (non-nuclear) field tests ...ducted by the Commission's Lawrence Radiation Laboratory ...ivermore) provided a basis for relating theory to practice, in-...mation on the safety of explosives application, and information ...the design and construction for tests of the applicability of nuclear ...plosives to peaceful uses.

Laboratory efforts were devoted to developing theories in two main ...s of explosion effects: (1) excavations, i.e., application to con-...ction of canals, harbors, water diversion projects, mining projects, ...d roads; and (2) contained-environment explosions, i.e., chemical ...ctions, oil recovery, mining projects, waste disposal, power produc-... and isotope production.



...e Location. Stylized map shows the location of Project Gnome, first nuclear ...ation in the Commission's Plowshare program (dark square, center of ...). The site is about 25 air-miles south of Carlsbad, N. Mex. Map also ..., the location of the potash mines, north of the project site, which were ...ated as an added safety precaution before the detonation took place. The ...are program is being conducted to develop peaceful and practical uses for ...er explosives in civil engineering, industrial projects, and scientific research.

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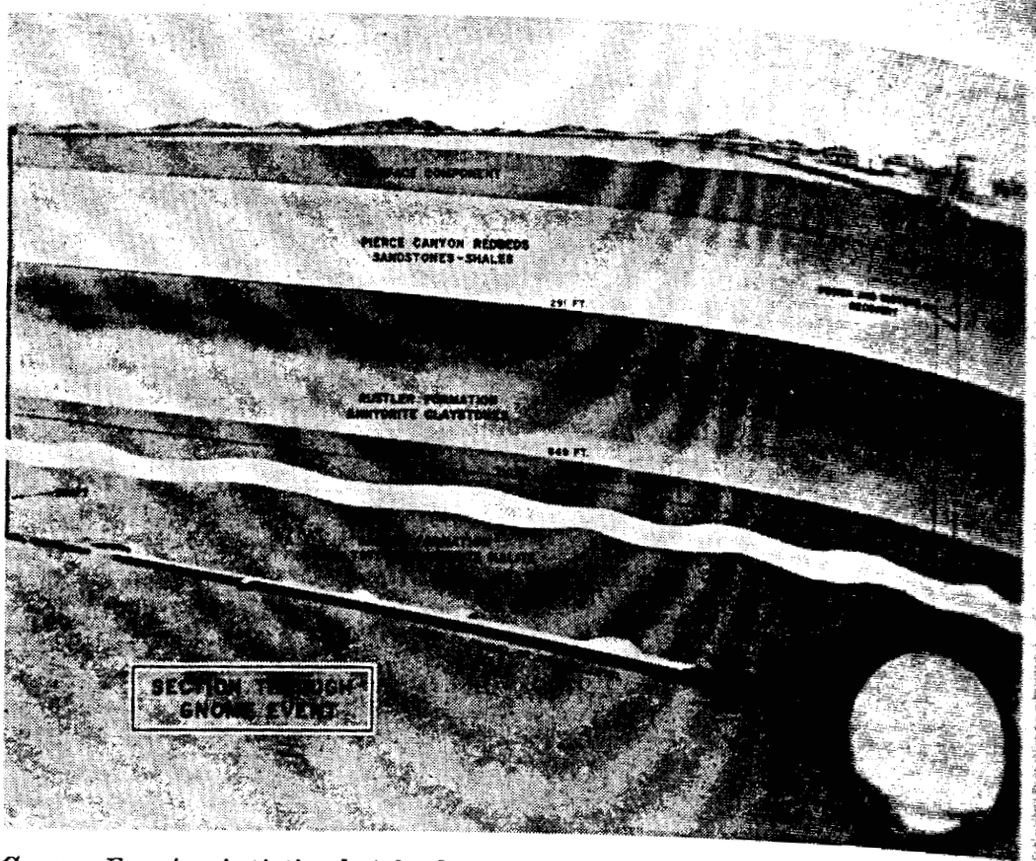

Gnome Event. Artist's sketch shows how a 1,200-foot shaft was sunk into the thick sub-surface salt bed and then a 1,000-foot tunnel was dug laterally to an underground chamber where the Gnome nuclear device was detonated on December 10, 1961. Lines on right of photo show where holes were drilled into the area of the detonation to make studies of isotope and power recovery.

Field Experiments

All Plowshare field experiments are conducted by the Office of Field Operations (formerly Office of Test Operations) of the Commission's Albuquerque Operations Office; the planning and laboratory work associated with the field tests is done by, or in conjunction with, the Commission's Lawrence Radiation Laboratory (Livermore).

Project Gnome

First of the several peaceful experiment nuclear detonations planned under the Plowshare program, Project Gnome was successfully carried out near Carlsbad, N. Mex., on December 10, 1961. The approximately five kiloton nuclear device was detonated in an underground chamber approximately 1,200 feet below the earth's surface in the Salado Salt Basin, a thick subsurface salt bed about 25 miles southeast of Carlsbad.

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he carrying-out of Project Gnome was the culmination of field which had been underway since March 1960, and planning h had been conducted since the formal inception of the Plow- Program in June 1957. President Kennedy announced his oval for conduct of Project Gnome on October 25, 1961, point- out that the Project was "a further example of this country's to turn the power of the atom to man's welfare rather than struction."

e project was conducted by the Commission's Office of Field ations and Lawrence Radiation Laboratory (Livermore), with ipation by Los Alamos Scientific Laboratory, Oak Ridge Na- l Laboratory, Sandia Laboratory, Stanford Research Institute, S. Bureau of Mines, U.S. Geological Survey, U.S. Coast and Geo- Survey, and Department of Defense. The U.S. Public Health ice, U.S. Weather Bureau, Edgerton, Germeshausen and Grier, and Holmes and Narver, Inc., also participated in technical and safety programs.

e Project was designed to provide scientific and technical in- ation for five major purposes: (1) the possibility of recovering al power from the heat generated by a nuclear explosion; (2) the sibility of recovering commercially or scientifically valuable iso- s produced by such explosions; (3) neutron physics and other ntific theory; (4) effects of a nuclear explosion in salt; and (5) rn principles useful in developing nuclear explosion devices ifically for peaceful purposes. In connection with each of these poses there were a number of experiments depending upon com- instrumentation, sophisticated scientific apparatus, above ground ng systems, post-shot drilling, and physical observation and meas- ents. The experiment was one of the most heavily instrumented y nuclear detonation conducted by the United States.

n December 10, 1961, the scheduled target date, the detonation took e at 12 noon, Mountain Standard Time. Over five hundred offi- observers, including nineteen from foreign countries, viewed the ation from a point four and one-half miles from the surface e the detonation chamber. The detonation had been delayed hours from the scheduled target time because of adverse surface conditions.

n addition to being the first nuclear detonation in the Plowshare gram and thus the world's first known nuclear explosion for peace- purposes, the detonation and its results, so far, mark a series of firsts. It was the first nuclear detonation conducted in the con- tal United States outside the Nevada Test Site since the Alamo- do, N. Mex., detonation in 1945. The cavity created by the explo-

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sion was the first known to have persisted for more than a brief period of time, confirming technical predictions and establishing the basic feasibility of a number of ideas which depend upon this effect.

At year's end, the tremendous job of analyzing and evaluating the data provided by the experiment had just begun. However, scientists working on the project believed that all experiments have yielded positive data. An extensive seismic research program was also conducted in connection with the detonation by technical personnel of the Department of Defense contractors in the Vela-Uniform program and by the U.S. Coast and Geodetic Survey. This program was considered highly successful. Seismic detection of the detonation has been reported from Japan and Sweden.

Immediately after the detonation, the ground surface above the explosion chamber heaved upward producing a permanent bulge found to be about two feet at its maximum point, and 2,400 pounds of high explosives located three-fourths of a mile from the surface zero point was detonated prematurely. The high explosives had been scheduled for detonation five minutes after the nuclear device to calibrate microbarograph recordings.

In connection with the explosion, which was contained underground and, as predicted, did not breach the surface of the earth, there was a release of radioactivity through the shaft, mostly in gaseous form. Very little radioactive particulate material was released to the atmosphere. The exact mechanism by which this escape of radioactivity occurred is not yet known. About five minutes following the detonation steam was observed issuing from the vertical shaft leading to the horizontal tunnel 1,200 feet underground. This flow continued for a few hours and then diminished, with a small flow visible through the next day. It appears likely that the steam released was created by the heating of the water naturally present in the salt around the detonation point. In order to insure public safety, precautions had been taken based on predictions of the extreme limits of credible events, singly or in combination.

The highest off-site recording of radiation at an inhabited place was one-twentieth of a roentgen per hour in transitory vapor that passed over a farm about ten miles northeast of Carlsbad. The highest of any field recordings occurred briefly on a highway 4.5 miles from the command post where readings showed 1.4 roentgens for a few minutes. The highway was blocked for more than two hours to avoid exposure to motorists. Seven vehicles, however, passed through the area prior to establishment of the road block, and later were washed to remove possible radioactive contamination.

On-site, a maximum reading of 10,000 roentgens per hour was recorded at the shaft head after the detonation. This decreased to 300

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gens per hour within five or six hours and to one roentgen per r by December 12. Within two days of the test, project employees re working in the vicinity of the shaft head without the need of ective clothing.

The safety program in other respects was also successful and no age to the Carlsbad Caverns, off-site facilities, or mines was de- ined during post-shot inspection surveys. Miners returned to erground workings of nearby potash mines after completion of inspections by late afternoon and evening of December 10.

Early qualitative and quantitative information indicated the follow- regarding the results of the experiment:

1. A cavity was formed and continues to persist. Re-entry into shot region by drilling established this on December 22, when the ll bit entered a void at 1,089 feet. The devise was emplaced at 54 feet. There was no steam nor pressure in this cavity at that . Later, on December 28, the second drill hole penetrated the ity and established what appeared to be a floor at 1,188 feet. In course of drilling through this floor on December 29, the drillers orted entering a "second void" at 1,235 feet. Penetrating twenty further into this "void" resulted in damage to the drill bit ap- ently caused by high temperature. At year's end, the temperature ime in the cavity had not yet been established.

2. Based upon the apparent durability of the cavity and the quali- ire indications regarding temperatures, it appears possible for a er measurement program to be undertaken to explore the possi- ity of recovering the heat released by the explosion. The lack of ssure in the cavity, which was apparently the result of the un- ned escape of steam, made pressure bleed-off unnecessary. The had been to introduce water to create the additional steam for power experiment. The effect of the escape of steam on the tem- ture is not known.

3. With respect to experiments relating to the feasibility of re- ring isotopes produced in a nuclear explosion, several approaches the problems involved were being explored. Prompt recovery ex- ments were conducted by the Oak Ridge National Laboratory and Livermore Laboratory using vacuum equipment on the surface to gaseous samples through a hole extending into the shot region. lysis of the samples is presently underway. Study of filters and substitute experimental techniques may provide information certain other approaches which originally depended upon the lated withdrawal of the steam created by the explosion. Addi- al approaches involve re-entry drilling and mining. One of the isotopes whose recovery was being studied was tritium. As pre-

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dicted, almost all the tritium was in the form of water vapor which suggests that isotopes present in gaseous phases may be easily recovered.

4. With respect to the basic research experiments being conducted by Los Alamos Scientific Laboratory and Lawrence Radiation Laboratory, the neutron wheels being used for the neutron physics experiments were recovered on December 16, 1961, and returned to the laboratories for examination. Both laboratories reported obtaining valuable data from their wheels. Basic chemistry experiments involved pre-shot placement of samples to study shock and pressure induced chemical changes and post-shot mining to recover the samples.

5. Physical effects studies are in progress and useful data have been and are being obtained. Extensive data in this area were being sought to extend knowledge of the characteristics of nuclear explosions to this new medium. Some instrument dependent results were lost, mainly due to cable damage. In connection with the physical effects of the detonation, it is interesting to note that the vertical shaft suffered no appreciable damage and is completely usable, and that the hoisting equipment is in excellent operating condition.

6. Data on the performance of the Plowshare device experiment was obtained and is being processed for analysis and evaluation. No information on the results of the experiment was available by the end of the year. If successfully proven, the design principles under study could lead to cheaper explosives with greatly reduced radioactivity. The device which was the energy source for the experiment and which had been adapted from an existing device, the design of which had previously been tested, provided sufficient yield for all experimental purposes.

Technical information developed in Project Gnome will be reported in the Commission's technical information system. Reports will become available for purchase from the Office of Technical Services, Department of Commerce, and will be placed in the Commission's depository libraries throughout the world.

An official observer program was conducted in two parts in connection with the Project. A tour of the underground facilities was conducted on November 26, 1961, with briefings on the preceding day. There were 197 official observers at the briefing, including sixteen from foreign countries; and 201 observers participated in the tour, including fourteen from foreign countries. As previously mentioned there were over 500 official observers present for the detonation. On December 9, a pre-detonation briefing was held, and a post-detonation briefing was held during the evening of December 10. Also there were a number of briefings conducted at the site during the day. In addition to the scientific and news media representatives of foreign

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Chariot Site. Aerial
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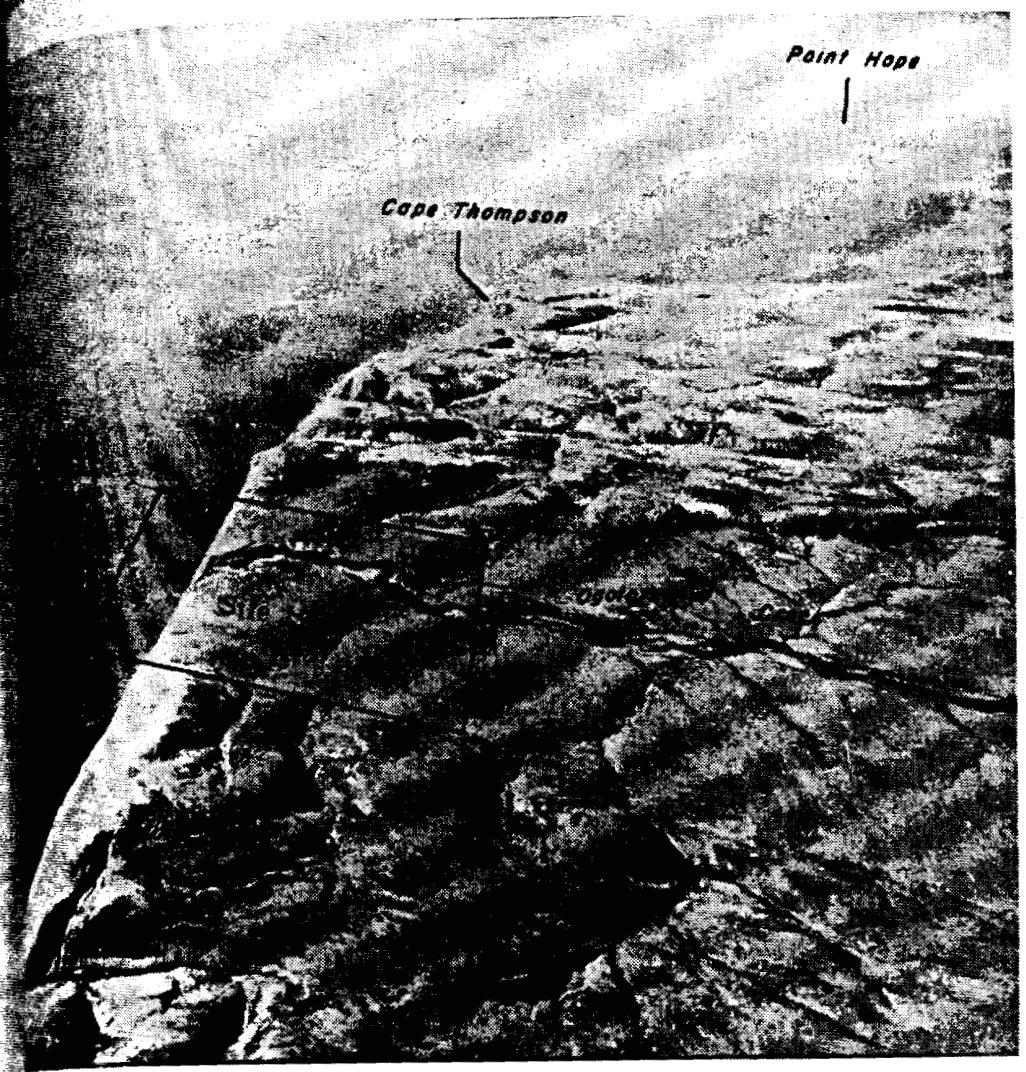
tries, there were representatives from Congress, the scientific community, industry, labor, organizations, federal, State and local government, area residents, and the news media. Altogether sixteen foreign nations and two international organizations were represented.



Site. Aerial view of the northern Alaska site under study for Project *Chariot*, a peaceful excavation experiment proposed for the Commission's Plowshare program. The experiment, if conducted, would provide for the underground detonation of four 20-kiloton and one 200-kiloton nuclear explosives which would create a model-scale harbor within the area enclosed by the black lines on photo. The purpose of the experiment would be to develop technology leading to the use of nuclear explosives in large-scale excavation work. To left of photo is the Chukchi Sea, a part of the Bering Strait.

Project Chariot

Scientific investigations continued on Project *Chariot*, a peaceful nuclear excavation experiment under study for the Cape Thompson area in northwestern Alaska. No authorization has been given for

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detonating nuclear explosives for this project, nor has any date for the proposed experiment been set. The proposal calls for simultaneously detonating underground, at depth of about 400 feet, four 20-kiloton nuclear explosives to excavate a ship channel, and one 200-kiloton nuclear explosive at about 800 feet to excavate a turning basin. Predicted dimensions for the channel are 900-feet wide, 200-feet maximum depth, and 2,000-feet long. The channel would connect the basin—1,800-feet in diameter and 400-feet maximum depth—with the ocean.

Intensive environmental studies [15] of the area surrounding the site have been made during the past several years by a team of scientists whose fields range from biology and human geography to geology, oceanography, and meteorology. These pre-detonation bioenvironmental studies continued through the report period. Safety and other aspects of the proposed project are still being evaluated. A determination of the feasibility of the proposed experiment will not be made until these studies and evaluations are completed.

The project is being planned by Lawrence Radiation Laboratory (Livermore), with field studies including teams from the University of Washington, the University of Alaska, the U.S. Fish and Wildlife Service, the U.S. Weather Bureau, the U.S. Public Health Service, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and Commission staff and laboratory personnel.

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Project Wagon

A low-yield nuclear cratering detonation for peaceful purposes is now being planned by the Commission's Livermore laboratory staff and would be conducted in a basalt formation at the Nevada Test Site. Called Project *Wagon*, it would yield important information for the application of nuclear explosives to excavation. Specifically, it would extend cratering experience to a new medium and provide information on the distribution of such radioactivity as may escape from the underground shot point. In addition, it would provide data on the critical relation between shot depth, size of crater, and possible escape of radioactivity.

[15] A summary of the first preliminary report on this environmental investigation appears in the appendix of the Commission's special report "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Management, 1961"; available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

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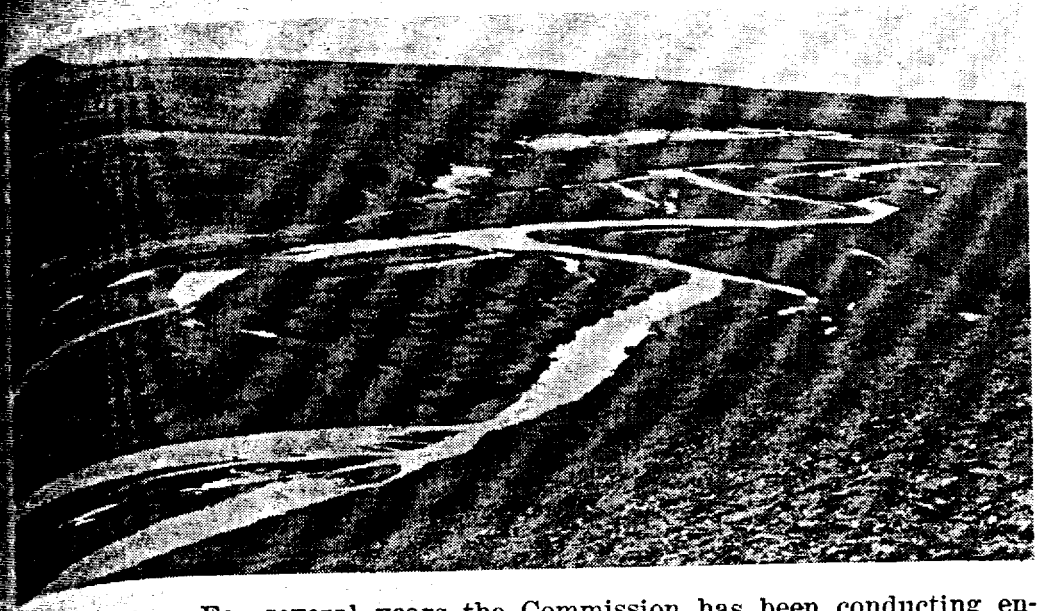

Chariot Studies. For several years the Commission has been conducting environmental investigations in the area of Alaska being studied as the site for Project Chariot. *Photo above* shows the lower reaches of Ogotoruk Creek, with the Chukchi Sea in the background, where the model-scale harbor would be created through nuclear explosives. *Photo below* shows two scientists from the Commission's Hanford, Wash., laboratories using a soil plug cutter to obtain samples of the insect life associated with different kinds of plants and soils in the proposed Project Chariot area. Such work is part of the overall environmental research being conducted to evaluate the effect such detonations would have on the ecology of the region.

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Project Coach

Planning of a project called *Coach* is underway at the Livermore Laboratory. This project would basically be a scientific experiment and would involve the detonation of a specially designed, several kiloton nuclear explosive with high neutron flux to study: (*a*) the production of neutron-rich isotopes of known transplutonic elements, and (*b*) the possible production of elements heavier than those yet discovered. Data obtained from this experiment should contribute to the scientific theory underlying this area. Re-use of the Gnome site is being considered for this project. This project has not yet been authorized and no date has been set for it.

Chemical High Explosive Experiments

Several chemical high explosive (non-nuclear) projects have been conducted to advance the basic knowledge necessary for planning peaceful nuclear excavation projects and for developing a theory of cratering. Among these projects was the *Scooter* event in the fall of 1960, involving the detonation of 1,000,000 pounds of TNT buried at a depth of 125 feet in desert alluvium. This resulted in a crater 307 feet in diameter and 75-feet deep. These dimensions were within a few percent of pre-shot predictions which were based upon a new empirical scaling law evolved by scientists at Lawrence Radiation Laboratory (Livermore) and the Sandia Laboratory. Earlier cratering studies were Project *Buckboard*, conducted in basalt by Sandia, and Projects *Toboggan* by Sandia and *Rowboat* by Livermore, which were experiments in the Playa Lake Bed at NTS, with line charges.

Field Safety Studies

The environs of the *Teapot ESS* in 1955, and *Buster Jangle* in 1951, nuclear-cratering-effects tests at the Nevada Test Site are under study to determine the amounts and availability of various radionuclides, such as strontium 90. Soils, plants, and animals from the crater and crater lip are being sampled and analyzed. Similar studies are being conducted near the explosion sites of *Rainier* (1957), *Blanca* (1958), and *Logan* (1958). These latter events were underground nuclear weapons development tests.

Laboratory Programs

Besides the theoretical and engineering efforts required in support of the field program, several laboratory programs for peaceful pur-

have been undertaken by the Lawrence Radiation Laboratory (Livermore).

Theoretical Developments

A theory for the behavior of radioactivity released from nuclear-cratering explosions has been developed. Tests of the theory could be conducted in the planned *Wagon* experiment. A tentative theory of explosive crater production has also been developed and will be used in future projects.

Explosive Development

Special nuclear explosives which minimize the costs, radioactivity, and difficulties of installation are being developed for use in peaceful projects. Considerable progress in calculation and concept has been made.

Strong Shock Research

Many beneficial results of underground nuclear explosions are attributed to effects of the strong shock generated by the detonation. Laboratory investigations of strong shocks in solid materials have been undertaken. Currently under development, are facilities for generating appropriate shocks and instruments for measuring important shock parameters. Equations of state of shocked materials involved in various Plowshare applications are being measured. Also under study at the Livermore laboratory are chemical reactions and other molecular changes which occur under shock conditions. Strong-shock measurements are being studied by Sandia.

Applications

Several detailed studies of specific peaceful applications are undertaken by Livermore. These studies are performed to determine economic and technical feasibility of the applications proposed for the Plowshare program, as well as to delineate safety considerations. They make use of the results of explosives and theory developments and provide criteria for additional theory and explosives research. Two studies—a model sea-level canal excavation by Sandia and an oil-field experiment—have been completed. Three others; block-caving mining model, water-diversion canal model, and brine-disposal model, are in various stages of completion at Livermore.

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NUCLEAR SAFETY PROGRAM

In developing military and peaceful utilizations of nuclear energy, the Commission must take due regard of the precautions necessary to protect the public, from the effects of nuclear radiation or any other form of hazard or damage that might arise from activities associated with the atomic energy program. The precautions that are undertaken in this regard, insofar as licensees are concerned, are discussed under Part 4—Regulatory Activities, of this report.

Responsibility for overall coordination of the wide range of safety factors that must be considered in association with such Commission activities as the PLUTO and ROVER reactor experiments, nuclear weapons testing, and the Plowshare program [16] has been assigned by the Commission to its Office of Field Operations. These responsibilities include not only the conduct of the experiment itself, but also such things as the construction of facilities, the housing of project-connected personnel, and the labor relations associated with the experiment. Although the carrying-out of an actual nuclear detonation is only one of the many functions concerning the Office of Field Operations, the successful conduct of the December 10 Project Gnome experiment, under the Plowshare program, increased the public awareness of the Commission's safety program in connection with nuclear detonations. Summarized below are examples of what is being done to assure public safety, particularly in connection with experimental underground nuclear detonations for peaceful purposes.

Office of Field Operations

Functional Responsibility

Originally established in 1950 as the Office of Test Operations, for the conduct of nuclear weapons tests, this agency of the Commission became the Office of Field Operations during 1961, with a much broader field of responsibility. It is under the supervision of the Manager, Albuquerque Operations Office. The Office is responsible for assuring that all nuclear safety factors are considered on a coordinated, knowledgeable, and systematic basis in the planning of test experiments, particularly those of a nuclear nature; and, in the case of detonations, for the carrying out of the actual detonation operation itself. This responsibility now extends to the Plowshare Program, Vela-Uniform Program,[17] certain reactor experiments (ROVER and

[16] See Plowshare program section.
[17] See Military Applications section.

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LUTO), weapons tests, and other test activities wherever they may conducted, when under Atomic Energy Commission auspices.

Additionally, the Office also executes many basic and applied research and study projects conducted in the fields of earth sciences, hydrology, meteorology, oceanography, and the many other areas of technology which bear on the underlying concerns with public safety as a result of test experiments, particularly nuclear. These research and study projects are carried out within the Commission, by other Government agencies in cooperation with the Commission, or by Commission contractors.

Public Safety Aspects

Public safety is defined under the above terms as being concerned with eliminating, or reducing to an acceptable minimum, any effects of the tests which could harm people directly or indirectly, or damage public or private property, or natural resources, during and after any Commission nuclear or high explosive test.

Under the Plowshare, Vela-Uniform, weapons, and reactor programs, the problems involved in assuring public safety are principally embodied in four general areas. Ground shock and its effect on both surface and subsurface features, either natural or man-made, must be considered. There must be assurance there will be no hazardous contamination of potentially usable ground water. A realistic appraisal must be made regarding airborne and surface contamination hazards that can affect people both on and off the test site. Air blast, thermal radiation, and some unique aspects of industrial safety (e.g., creation of cavities in salt and other media), must also be taken into account. A negative response to consideration of any one of these problem areas may be considered adequate justification for postponement, cancellation, or change of location or type, of a planned test. For instance, the Project Gnome experiment was delayed four hours until a wind shift occurred that would carry any release of radioactivity away from nearby populated areas. While a radioactivity release was not expected, it was foreseen as a possibility under the safety planning—and it did occur.

Major Actions During 1961

On June 15, 1961, the Office of Field Operations (OFO) entered into a contract with Roland F. Beers, Inc., of Alexandria, Va., to undertake long-range studies in the broad field of earth sciences. The contractor is to perform long range studies leading to improved ability to predict hazards to public safety; correlate existing data,

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identify gaps in knowledge, recommend programs for filling such gaps, and formulate and monitor programs of long range research to develop improved theories and data.

The OFO has arranged with other Government agencies, including the U.S. Geological Survey, U.S. Bureau of Mines, U.S. Coast and Geodetic Survey, U.S. Public Health Service, and various laboratories and technical contractors to continue to conduct special, as well as long range studies and investigations, in keeping with their respective fields of responsibility. These activities were greatly increased during 1961 under the guidance and coordination of OFO in the interest of public safety as nuclear weapons testing was resumed and approval to conduct Project Gnome, a Plowshare program activity, was received from the President. At the same time, and as result of intensive studies of pre-1958 test data made during the 1958–1961 test suspension, improved cooperation developed in coordinating technical information. This has resulted in expanded comprehensive public safety programs and in improving, by means of more extensive technical data, the public information and education programs which, to be effective, are primarily dependent on substantiated technical information.

Operations Planning

Simultaneously with the laboratory planning for a specific experiment, the OFO undertakes field evaluations to determine the surface and subsurface geology of the region of interest by studies of existing data and additional field evaluations. Geophysical information from existing data, or from additional seismic shock measurements, is obtained to ascertain the boundaries of a selected medium and the characteristics of the medium and the surrounding sediments.

When necessary, exploratory drilling is performed to obtain both the essential geologic and hydrological knowledge in the regions of interest. These drill holes may be for the purpose of locating water-bearing aquifers, measuring their physical and chemical characteristics, defining boundaries and physical characteristics of geologic masses of specific technical interest, determining geologic composition at various locations and depths over and around the specific shot area, or determining the characteristics of the surrounding media regarding the transport of radioactive constituents generated by the detonation. Involved as byproducts of such drilling programs, are evaluations of core-hole and deep-well logs of all kinds taken during the drilling programs, including electric, gamma ray, neutron, induction, seismic velocity, and continuous acoustic velocity logs.

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[a] See p. 216 of this

When this work is completed and the data is analyzed, valid predictions may then be made on:

Maximum particle motion on the surface and underground which will result from the detonation, including range of frequencies expected at maximum damage-producing values of motion.

Probability of damage from these motions as a function of distance from the shot.

Probability of surface ground subsidence subsequent to the shot.

Probability of fracturing the shot medium (e.g., a salt mass) and the contiguous sediments in such a mannner as to constitute a hazard to surrounding ground water supplies.

In addition, fresh water supply wells within a large radius of the shot site are inventoried, to derive data on sizes and depths of wells, water levels, specific well capacities, chemical and radiochemical characteristics of the water, and the background radioactivity to total depth of wells.

These activities are carried on during the pre-shot exploratory period, and a considerable number of post-shot activities are planned to verify validity of predictions and to determine any changes in the geologic and hydrological environment, as well as any changes in surrounding surface features.

These steps, generally, are the broad safety actions taken in evaluating the ground shock and contamination hazards. Other effects, particularly air blast and thermal radiation, may likewise be involved. The effects of air blast may require evaluation, depending on the depth of the shot, its yield, the medium in which it will be detonated, and other factors. If blast is a factor (as in the *Chariot*, *Wagon*,[18] and cratering experiments conducted relatively close to the surface), the necessary blast safety predictions may be developed from experience gained during weapons tests, and from recently refined techniques developed by Sandia Laboratory for evaluating atmospheric conditions and blast propagation under a specific test situation. In addition, a Commission contractor, Holmes & Narver, Inc., in the course of its work on designing blast-resistant structures for the Commission has also developed a considerable ability to predict damage from air blast. Thermal radiation (with the hazard of flash blindness and retinal burns) is an area in which substantial knowledge has been developed during past weapons testing. Primarily, it poses the operational problem of assuring that people are far enough away from ground zero and are not looking directly toward the point of detonation. Under pres-

[18] See p. 216 of this report.

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ent and contemplated Plowshare or Vela-Uniform programs it is not a real problem at most since these will be underground tests. Although nuclear explosions release vast quantities of thermal energy, this energy is relatively easily suppressed to the shot site even at much shallower depths than any tests now contemplated.

Hazard Evaluation Work

A rather broad group of Commission contractors and Government agencies become involved in the function of hazard evaluation and planning for safety prior to any test. The Commission scientific laboratory sponsoring the field experiment performs the first evaluation as part of concept planning and continues to participate in evaluations and planning throughout the operation. A number of Government agencies, particularly U.S. Public Health Service, U.S. Geological Survey, U.S. Coast and Geodetic Survey, U.S. Bureau of Mines, and U.S. Weather Bureau contribute to the planning in their areas of special competence. Two Commission prime contractors, Sandia Corp. and Holmes & Narver, Inc. (both of whom have been identified with nuclear detonation program work for a number of years) along with other Commission contractors and scientific and technical consultants, likewise participate in the evaluation, prediction, and planning for safety of the experiment. A formal safety plan is developed by the Office of Field Operations for each field event, representing the concerted efforts of this total organization and covering in detail all elements of the program.

INTERNATIONAL ACTIVITIES

The Commission's international activities continue to be directed toward greater world-wide utilization of atomic energy for peaceful purposes. During 1961, the Commission:

- Recommended to the President and received approval for increasing the availability of enriched uranium for peaceful uses abroad from 50,000 kilograms to 65,000 kilograms of contained uranium 235.
- Contributed some $2.5 million to seven nations as monetary aid for nuclear research reactors and equipment.
- Participated to an increasing degree in technical cooperation activities with advanced nuclear energy projects of Western Europe and Canada.
- Participated in, and supported, a broad spectrum of International Atomic Energy Agency activities, including the Fifth General Conference, which confirmed the selection of Dr. Sigvard Eklund of

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Sweden to succeed Sterling Cole of the United States as the Agency's Director General.

- Initiated negotiations with the International Atomic Energy Agency (IAEA) concerning the application of IAEA safeguards to the United States reactors offered during the 1960 General Conference as a means of demonstrating effectiveness of the safeguards procedures and policies adopted by the Agency.
- Participated in multi-nation meetings on the development of international conventions to govern liability for nuclear damage caused by land-based and maritime reactors.
- Joined with *Euratom* in the issuance of a second invitation for proposals to construct large-scale nuclear power plants in Western Europe which would be in operation by December 31, 1965.
- Participated in 24 international conferences, and had two large "Atoms at Work" exhibits touring South America and the Middle East.

International Cooperation Trend

The peaceful atomic energy programs of more than a score of nations benefited from United States assistance and cooperation during the past year. The Commission's efforts in this field encompass reactor and equipment grants; information exchanges, including library grants; long and short term visits; the furnishing of technical advice and consultants; training foreign nationals at Commission facilities; and the sale or lease of nuclear materials. Because of the growth of the scope and intensity in the nuclear programs of many countries throughout the world, the United States nuclear cooperation program has had to meet new and increased demands in most of those activities.

In addition to its expanding nation-to-nation cooperation, the United States continues to provide substantial support and encouragement to international organizations such as the International Atomic Energy Agency (IAEA) and the Inter-American Nuclear Energy Commission (IANEC) in their efforts to promote peaceful nuclear activities, particularly among the developing nations. United States cooperation in the programs of international nuclear energy organizations is significant not only for the early development of productive programs among the members states of these organizations, but for the contributions that such organizations make to the establishment of international standards and conventions, the exchange of scientific information, and the fostering of cooperative research and development on an international scale.

A significant aspect of the U.S. program of international cooperation in nuclear energy is the increasing tempo of joint efforts with other nations and international organizations on advanced research

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and development projects. United States assistance to foreign programs continues to be of major importance. However, the U.S. nuclear energy program is benefiting, in return, on an increasing scale from the Commission's participation in the DRAGON and Eurochemic projects; from information exchanges on fast reactor technology with the United Kingdom and France, and with West Germany on the pebble bed reactor; and from our joint effort with Canada in heavy water reactor technology.

The U.S. role as a supplier of materials is another phase of the program that assumes increasing importance with the growth of nuclear energy activities abroad. Transfers of special nuclear and related materials from the United States to other countries have increased markedly in recent years. This trend is expected to be accelerated by announcements during 1961 concerning the long-range availability of U.S.-produced enriched uranium.

TABLE 3.—U.S. ATOMS FOR PEACE ASSISTANCE [a]

	Agreements for cooperation [b]	Research reactor grants	Foreign visitors (annual)	U-235 (Kgs)	Technical depository libraries
1955	22	----------	335	19	[illegible]
1956	32	4	1, 136	23	[illegible]
1957	37	7	2, 261	64	[illegible]
1958	42	16	3, 165	209	[illegible]
1959	44	19	4, 340	315	[illegible]
1960	41	22	5, 493	642	[illegible]
1961	39	24	6, 607	[c] 1, 049. 7	[illegible]

[a] Cumulative except as otherwise noted.
[b] In effect during year.
[c] As of November 30, 1961.

POWER REACTOR ASSISTANCE

Issuance of the United States-Euratom second round invitation for power reactor proposals, and the U.S. offer to Euratom of the option for purchase or lease of reactor fuel, highlight U.S. participation in the development of power reactors abroad during 1961.

Euratom Second Round Invitation

On September 2, the Commission and Euratom issued an invitation for proposals from private or governmental organizations within the European Atomic Energy Community—Belgium, France, The Federal Republic of Germany, Italy, Luxembourg, and The Netherlands—for the construction of large-scale, nuclear powerplants to begin operating not later than December 31, 1965. Preference will

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given to proposals for reactors having a nuclear capacity of at st 150,000 electrical kilowatts (ekw) net although smaller plants ll be considered if they present some special interest for the overall ctor program.

As with the first invitation in 1959, reactors must be built, owned, d operated by enterprises in the Community. The reactors also st be of a type which have reached an advanced stage of development in the United States.

Under terms of the joint program, special benefits available to projts for participation include a 10-year fuel element guarantee, longm capital loans to cover part of the plant construction costs, and g-term assurance of an adequate fuel supply at prices comparable those offered U.S. industry.

The program also assures, over a 10-year period, a market for pluium recovered from the reactors and provides long-term assurance the United States that chemical reprocessing services will be availe on the same terms as offered U.S. industry. The cut-off date for mission of proposals under the second invitation is June 1, 1962.

The *Franco-Belgian Society for Nuclear Energy of Ardennes* ENA) submitted the first proposal under the second invitation with ns for a 210,000 electrical kilowatt, pressurized water reactor sta- to be built near Givet, France. A group of seven French comies (FRAMATOME), three Belgian firms, and the Westinghouse ctric International Co. would supply the plant equipment. The ctor would be located deep within a hill at a bend in the Meuse er. Another nearby cavern would house auxiliary equipment, ile the electric generating unit would be installed in a building side.

The 150,000 electrical kilowatt boiling water reactor plant being lt near Punta Fiume, Italy, by the *Societa Elletronucleare Nazio-* (SENN) is the only facility being constructed under the first U.S.-Euratom joint invitation.

l Supply

A reduction in prices for enriched and depleted uranium, and an ease from 4 to 4¾ percent in the use charge for fuel leased for estic purposes were announced by the Commission on July 1, 1961. equently the Commission offered Euratom the alternatives of hasing fuel on a deferred payment plan [19] at the domestic base ge with a four percent interest rate, or leasing the fuel at domestic ges (including the 4¾ percent use charge) with the United States

[19] Under the deferred payment plan, payment is extended over a 20-year period, with the nt country paying only the four percent interest rate during the first 10 years. ent on the principal would be made in 10 equal increments during the following 10 with an interest rate of four percent on the unpaid balance.

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having the option of converting the lease agreement into sale, should lease agreements be terminated for United States domestic users. In August the Societa Elletronuclear Nazionale (SENN) advised the Commission of its decision to accept the deferred payment plan for obtaining fuel for their 150,000 ekw boiling water power reactor being constructed near the mouth of the Garigliano River in Italy.

Previously, on July 25, SENN and Euratom had signed the contract relating to the first project under the United States-Euratom joint power reactor program. In a separate action, SENN signed an agreement with the Commission which enables it to qualify for fuel element guarantees for 10 years providing it meets certain requirements and applies for specific guarantees for individual cores. These guarantees serve to limit the financial risk of the utility.

International Cooperation. Photo shows Euratom President Etienne Hirsch (left) and Commission Chairman Glenn T. Seaborg (right) during the former's July visit to Washington, D.C. During the visit, details were worked out for continued cooperation between the Commission and Euratom. On the table are special, single crystals of UO_2 which had been prepared at the Commission's Hanford plant and were presented to M. Hirsch for distribution to interested Euratom contributors for their use in making physical property measurements.

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t Research and Development Program

Support continued for the United States-Euratom Research and elopment Program which includes work on those types of power ctors to be built under the U.S.-Euratom cooperative program. rteen new contracts were authorized for work in the United States ring 1961. An additional 25 new contracts were authorized for rk in Europe in 1961.

Marine Propulsion

Savannah Foreign Acceptance Agreements

Representatives of the Commission and the U.S. Maritime Admin-ration have met with nuclear, maritime, and public health officials Belgium, Denmark, France, Germany, Greece, Italy, Norway, The therlands, Portugal, Spain, Sweden, and the United Kingdom to elop in-port acceptance agreements for the NS *Savannah*. In eral, negotiations are progressing satisfactorily on matters related general operating conditions, safety evaluation, and inspection. conclusion of acceptance indemnity arrangements continues to sent problems which it is hoped can be resolved through mutual rt.

erest in Marine Nuclear Propulsion

There is interest in marine nuclear propulsion among some of the clearly-advanced nations. By the end of 1961, Euratom expects conclude contracts for nuclear ship projects with firms in Italy, Netherlands, and Germany. The Commission is not directly par-ipating in any of these projects. However, *Interatom*, a German iate of the U.S. firm, Atomics International, entered into a con-t with another German firm, *GKSS*, and Euratom on January 1961, for the design of an organic-moderated and cooled reactor e installed in a 10,000 shaft horsepower experimental vessel. No sion on proceeding with construction is expected until about l-1962.

Materials

Two Commission decisions in 1961 regarding nuclear materials have cted the international program to a limited extent this year and be expected to have a greater impact in future years. One of , the revision in the price schedule, has already been described in above section on Power Reactor Assistance.

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Fuel Fabrication

The second important decision was the approval of a policy permitting other nations to amend their bilateral agreements with the United States so that they may fabricate U.S.-supplied special nuclear material for use in third countries. This step is particularly significant in view of the increasing number of arrangements which U.S. firms concluded during the year for joint endeavors with nuclear energy firms in other countries. To date, Euratom, Germany, Canada, France, and Switzerland have expressed interest in entering into such an arrangement with the United States. As fuel fabrication capacity abroad is increased more countries are expected to desire such agreements.

In support of its previously-announced intention to provide for the reprocessing of spent fuel from foreign reactors under terms of agreements for cooperation, the Commission designated its Savannah River and Idaho Operations Offices as facilities which would accept foreign spent fuel for reprocessing during the interim period until U.S. private facilities can perform this service on a competitive commercial basis.

Introduction of Multi-Lease Agreements

As a step toward simplifying the procedures of leasing material for foreign research and test reactors and standardizing lease provisions, the concept of blanket, or multi-lease, contracts was introduced during 1961. This form of contract enables a foreign user to obtain enriched uranium for all its projects under a single contract rather than negotiating a new contract for each different shipment, as was the former practice. The multi-lease concept has been in use for domestic purchasers for several years. Multi-lease agreements were negotiated with Japan, France, Germany, Greece, Italy, Korea, Israel, and Belgium during 1961, and more are expected to be concluded during 1962, replacing the older individual material contracts.

Nuclear Materials Shipping Problem

One of the most significant materials problems affecting the Commission's international program has been the increasing number of instances in which the transportation of nuclear materials has been refused or delayed pending the resolution of hazards questions and insurance coverage for the carrier of the material and the facilities involved. Ocean shippers have been reluctant to accept nuclear fuel

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ipments because of the nuclear exclusion clauses in their insurance, d several airlines have similarly refused to carry special nuclear aterial.

Representatives of the Commission's Division of International Af- rs, in cooperation with the Divisions of Licensing and Regulation, nstruction, and Operational Safety have initiated an educational ogram designed to clarify the hazards involved and to explain the asures being taken to assure safe handling of radioactive materials transit. As part of this program, a series of meetings is planned th East, Gulf, and West Coast shippers. The first such conference s held July 26 and 27 in San Francisco.

In addition, a committee has been established to anticipate and lv problems arising in connection with the international shipment irradiated materials. Of specific interest are procedures being ablished to permit shipments of radioactive material through the ama Canal, and various domestic ports.

Under a contract with the New York State Office of Atomic Devel- ent, Ebasco Services, Inc., completed during 1961 a survey of the te's port facilities to determine their capability to construct and vice atomic-propelled vessels and to handle the shipment of pack- d radioactive materials, including used nuclear fuels. This survey, first of its type in the United States, provides not only specific on the handling of nuclear shipments through New York ports also other information of interest in relation to the international domestic shipment of radioactive materials.

U.S. Participation in IAEA Activities

ction of New Director General

At the Fifth General Conference of the International Atomic ergy Agency (IAEA) held September 26–October 6, the United tes delegation supported the action taken by the Conference in con- ing the Board of Governors' selection of Dr. Sigvard Eklund to ed Sterling Cole of the U.S. as Director General. John A. Hall, merly the Commission's Assistant General Manager for interna- al activities was appointed a Deputy Director General under Dr. and.

erials Transfers Through IAEA

Under an agreement with Norway and the International Atomic ergy Agency, the United States will transfer to Norway through

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the Agency and on a lease basis, a fuel core enriched to three percent in uranium 235 for use in the NORA, a zero-power natural uranium research reactor. The reactor is to be used jointly by Norway and the Agency in a three-year program to obtain basic nuclear data applicable to power reactor design, including maritime applications. The U.S.-supplied fuel core was originally used in developmental work for the NS *Savannah*, the United States' first nuclear-powered merchant ship. Two additional cores for the project will be supplied by Norway.

In October, the Commission agreed to transfer through the IAEA to Yugoslavia approximately 13,000 grams of 20 percent enriched uranium for fuel elements for a TRIGA Mark II research reactor, and approximately 5 grams of 90 percent enriched uranium for three fission counters for the reactor. In both instances, the IAEA will apply the safeguard provisions of its statute to assure that the material furnished through it will be used only for peaceful purposes.

Safeguards

The Commission continued to cooperate with the U.S. Department of State in securing acceptance of workable principles and procedures for international control of atomic energy materials and equipment by the International Atomic Energy Agency. On January 31, the IAEA Board of Governors approved a set of guidelines for Agency safeguards and put them into effect subject to a review after two years.

This action represents the first time that international agreement, more extensive than regional conventions, has been reached on procedures for international inspection in the field of atomic energy. The safeguards procedures will be reviewed by the IAEA in 1962. The approved safeguards are designed to apply to nuclear materials and equipment supplied by the Agency or to other materials and equipment at the request of supplying and recipient nations.

The United States and other non-Communist countries were also successful in obtaining, on June 29, the approval of the Board of Governors for a method of recruiting a Director and professional members of the IAEA Division of Inspection. A Soviet amendment, which would have divided the Inspectorate into representatives of the West, the Communist Bloc, and neutral countries, was defeated.

The United States offer [20] to place four of its reactor facilities under IAEA safeguards for an agreed period of time has progressed to the

[20] See p. 205, Annual Report to Congress (January–December 1960).

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nt of final negotiation. The Commission approved the basic U.S. otiating position on May 31. The four facilities, the Brookhaven phite Research Reactor, the Brookhaven Medical Research Re-or, the Experimental Boiling Water Reactor, and the Piqua Nu-r Power Facility were visited in September by two key members of Agency staff for the purpose of familiarization with the facilities first step in negotiations. The safeguards contemplated for the year agreement include periodic inspection by an IAEA team to ify peaceful use of the facilities and also periodic reports concern-the usage of the nuclear equipment and materials in the facilities. iled negotiations for implementation of the offer are currently progress.

To give further support to IAEA safeguards, the Commission pted the Agency's principles and procedures as the specific safe-rds to be applied under its bilateral agreements, where appropriate. Commission also continued to cooperate with the U.S. Depart-nt of State in efforts to maintain a common front on safeguards ng nations supplying nuclear assistance.

At the September, 1960, IAEA General Conference, the United tes and several of its bilateral partners announced their willingness ransfer to Agency administration the safeguards contained in their teral agreements.[21] During 1961, steps were taken to implement objective. The United States and Japan have jointly notified Director General of the Agency that the two governments are pre-d to enter into consultations with the IAEA with a view to the nulation of an appropriate agreement for this purpose.

Already a total of 11 countries have indicated a willingness to con-with the United States concerning such a transfer. Additional tries, with which the United States presently cooperates directly r a bilateral agreement, have indicated that they will seek future stance through the IAEA. Table No. 4 lists the bilateral agree-ts presently in effect.

ring 1961 the Commission, under the bilateral safeguards pro-conducted inspections of an increased number of nuclear facili-in foreign countries. Appendix 12 shows the reactors subject to guards inspection.

BILATERAL SAFEGUARDS INSPECTIONS
TO NOVEMBER 30, 1961

	1960	1961
ber of facilities inspected	33	41
ber of countries visited	12	18
able reactors subject to safeguards	40	56

[21] page 204, Annual Report to Congress (January–December 1960).

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TABLE 4.—STATUS OF AGREEMENTS FOR COOPERATION IN THE CIVIL AND MILITARY USES OF ATOMIC ENERGY AND SPECIAL AGREEMENTS

Countries	Agreements	Country	Scope	Effective Date	Termination Date
1	1	Argentina	Research [b]	7-29-55	[illegible]
2	2	Australia [a]	Research & Power	5-28-57	[illegible]
3	3	Austria	Research	1-25-60	[illegible]
4	4	Belgium [a]	Research & Power [b]	7-21-55	[illegible]
5	5	Brazil	Research [b]	8-3-55	[illegible]
6	6	Canada [a]	Research & Power [b]	7-21-55	[illegible]
7	7	China, Republic of	Research [b]	7-18-55	[illegible]
8	8	Costa Rica	Research	2-8-61	[illegible]
9	9	Cuba	Research	10-10-57	[illegible]
10	10	Denmark	Research [b]	7-25-55	[illegible]
11	11	Dominican Republic	Research	12-21-56	[illegible]
12	12	Ecuador	Research	2-6-58	[illegible]
13	13	France	Research & Power [b]	11-20-56	[illegible]
14	14	Germany, Federal Republic of	Research & Power [b]	8-7-57	[illegible]
	15	West Berlin, City	Research	8-1-57	[illegible]
15	16	Greece	Research [b]	8-4-55	[illegible]
16	17	Guatemala	Research	4-22-57	[illegible]
17	18	Indonesia	Research	9-21-60	[illegible]
18	19	Iran	Research	4-27-59	[illegible]
19	20	Ireland	Research [b]	7-9-58	[illegible]
20	21	Israel	Research [b]	7-12-55	[illegible]
21	22	Italy	Research & Power [b]	4-15-58	[illegible]
22	23	Japan	Research & Power [b]	12-5-58	[illegible]
23	24	Korea, Republic of	Research [b]	2-3-56	[illegible]
24	25	Netherlands [a]	Research & Power [b]	8-8-57	[illegible]
25	26	Nicaragua	Research	3-7-58	[illegible]
26	27	Norway	Research & Power	6-10-57	[illegible]
27	28	Philippines	Research [b]	7-27-55	[illegible]
28	29	Portugal	Research [b]	7-21-55	[illegible]
29	30	South Africa	Research & Power	8-22-57	[illegible]
30	31	Spain	Research & Power	2-12-58	[illegible]
31	32	Sweden	Research [b]	1-18-56	[illegible]
32	33	Switzerland	Research	7-18-55	[illegible]
	34	Switzerland [a]	Power [b]	1-29-57	[illegible]
33	35	Thailand	Research [b]	3-13-56	[illegible]
34	36	Turkey	Research [b]	6-10-55	[illegible]
35	37	United Kingdom [a]	Research & Power [b]	7-21-55	[illegible]
36	38	Venezuela	Research & Power	2-9-60	[illegible]
37	39	Viet-Nam	Research	7-1-59	[illegible]

SPECIAL AGREEMENTS [c]

1. European Atomic Energy Community (Euratom)	Joint Nuclear Power Program	Feb. 18, 1959
2. European Atomic Energy Community (Euratom)	Additional Agreement	July 25, 1960
3. International Atomic Energy Agency (IAEA)	Supply of Materials, etc.	Aug. 7, 1959

See footnotes at end of table.

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TABLE 4.—STATUS OF AGREEMENTS—Continued

MUTUAL DEFENSE PURPOSES AGREEMENTS [c]

NATO [a]	Mar. 29, 1956
Australia [a]	Aug. 14, 1957
Canada [a]	July 27, 1959
France	July 20, 1959
France [a]	Oct. 9, 1961
Germany, Fed. Rep. [a]	July 27, 1959
Greece [a]	Aug. 11, 1959
Italy [a]	May 24, 1961
Netherlands [a]	July 27, 1959
Turkey [a]	July 27, 1959
United Kingdom [a]	Aug. 4, 1958
(Amendment to U.K. Agreement) [a]	July 20, 1959

SUMMARY

In effect: 25 research and 14 power agreements with 37 countries and West Berlin, 11 Mutual Defense Purposes Agreements, and 3 special agreements (IAEA and Euratom). Although 5 other agreements have been signed, there are no present plans for ratification of 4 of them (Cuba, Iraq, Peru and Panama). The fifth, Brazil, still anticipates ratification.

[a] Classified Agreements.
[b] Denotes Agreement has been amended.
[c] Only the effective date shown for these agreement.

COOPERATION WITH THE U.S.S.R.

The possibilities of United States and Soviet cooperation in peaceful uses of atomic energy were first raised by U.S. representatives and were the subject of informal discussions between former Commission Chairman John A. McCone and Professor Vasily S. Emelyanov during the latter's visit to the United States in September 1959 with Premier Nikita Khrushchev of the U.S.S.R. Preliminary agreement was reached at that time on an initial reciprocal exchange of visits to unclassified facilities. In October 1959, a United States delegation headed by Chairman McCone visited Soviet atomic energy facilities, and the exchange was completed in the following month with a visit to U.S. unclassified facilities by a Soviet delegation headed by Professor Emelyanov.

Following the Soviet visit in November 1959, the formal Memorandum to cover future exchanges of personnel, information, and other cooperation in unclassified atomic energy fields was signed in Washington by Chairman McCone and Professor Emelyanov.[22] It

[22] See pp. 97–98, Annual Report to Congress of the Atomic Energy Commission for 1959.

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has been implemented within the framework of the U.S.-U.S.S.R. Scientific, Technical, Educational, and Cultural Exchange Agreement for 1960–61.

Under the Memorandum, provision is made for cooperation in the following areas: Reciprocal exchanges of visits by U.S. and Soviet scientists in controlled thermonuclear research, nuclear power reactor developments, high energy physics, nuclear physics, neutron physics, and structures of nucleons; and for exchange of unclassified technical information; and discussions of the feasibility of engaging in unclassified joint projects in the peaceful uses of atomic energy. The International Atomic Energy Agency will receive copies of all exchanged reports and memoranda on results of exchanges of visits. The Agency also will be invited to participate in U.S. and Soviet consideration of possible joint projects.

Reciprocal unclassified exchanges of visits by high energy physicists and specialists in the field of controlled thermonuclear reactions were completed in 1960. Discussions have been held by U.S. and Soviet scientists concerning the scientific and technical desirability of constructing a large and novel accelerator.

Under the Memorandum the U.S. forwarded abstracts of unclassified work in the peaceful uses of atomic energy and has received reports of recent work of Soviet scientists. The Soviet reports have been translated and made available to the U.S. scientific community.

Both parties have submitted proposals for exchanges of visits in the fields of waste disposal and power reactor development and the visits are expected to be implemented once agreement on the itineraries is reached.

Consideration is being given to extending the Memorandum of Cooperation for another two years at the time the over-all U.S.-U.S.S.R. Exchange Agreement is renewed. The extension would provide for implementation of uncompleted exchanges mentioned in the Memorandum and for further exchanges of visits and technical information in nuclear energy matters.

Nuclear Liability

During 1961, the United States was represented at two international conferences dealing with nuclear liability—one concerning land-based reactors, the other for maritime reactors.

Maritime conference. Among the international maritime law questions considered during an April conference held in Brussels, was that of liability of operators of nuclear powered ships. On the basis of proposals submitted by the International Maritime Committee and

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International Atomic Energy Agency, the conference drafted an international nuclear liability convention which was then referred to 57 countries represented for consideration. A second conference expected to be convened early in 1962 for the purpose of signing convention revised in accordance with suggestions received from the participating countries.

Land-based reactors. On May 3, the United States joined in an IAEA-sponsored, 14-member intergovernmental meeting in Vienna to consider a draft international convention on "Minimum International Standards Regarding Civil Liability for Nuclear Hazards" arising from land-based nuclear installations, and the transportation of nuclear materials. The draft convention is expected to be circulated to all IAEA member governments for their consideration.

Other activities. In June, the Euratom Council of Ministers agreed on a formula for apportioning nuclear liability responsibility among its six member states and a draft convention is now being completed. The United States is not a participant in these negotiations, but is providing advice and assistance upon request and will comment on the draft.

The convention being developed by Euratom member states is intended to supplement a nuclear liability convention signed in Paris in 1960 by 16 members of the then Organization for European Economic Cooperation (now Organization for Economic Cooperation and Development) and still in the process of being ratified by the member states. The Paris convention provides that operators of nuclear facilities shall be liable for damages up to a maximum of $15 million per accident, with member countries having the right to reduce this to a minimum of $5 million.

Under the Paris convention, damages above the coverage up to a maximum of $70 million would be paid by the country in which the installation is located. Damages from $70 million to the limit of $120 million would be paid from a Euratom fund.

Research Reactor, Fuel and Equipment Grants

Greece, Portugal, the Republic of China, Norway, Israel, and Belgium received United States reactor grants of $350,000 each for research reactors completed in those countries during 1961. A commitment was made to present a similar grant to Indonesia upon the completion of a research reactor being built at the Institute of Technology at Bandung, Java. All of the reactors, except Norway's NORA, which was built by Norway itself and Belgium's BR–2, are of United States manufacture.

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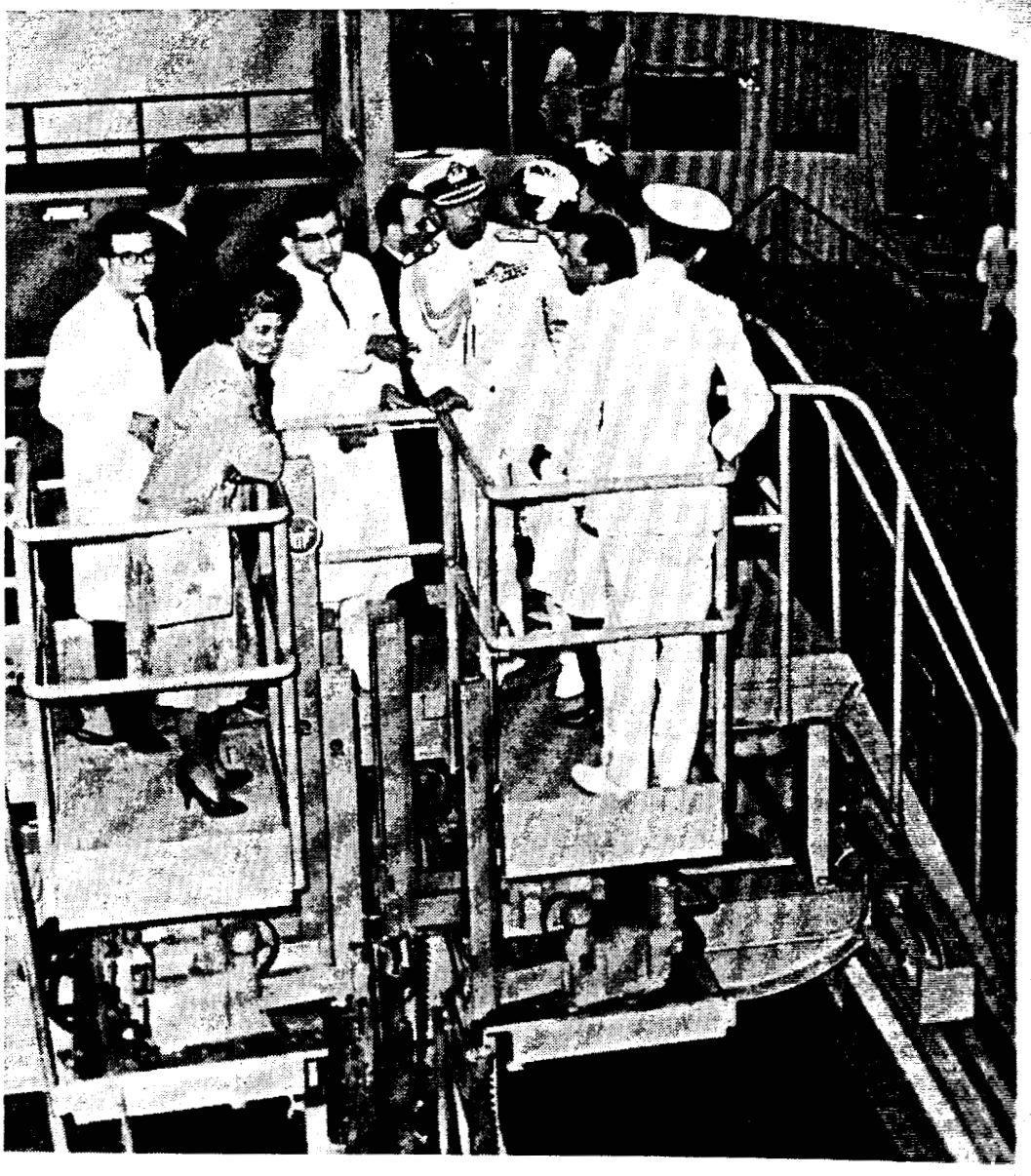

Royal Interest. Queen Frederika and King Paul of Greece are shown inspecting the United States-built, pool-type research reactor which was installed in Athens during 1961. The Greek Government received a Commission grant of $350,000 toward the cost of the 1,000 thermal kilowatt reactor. During her visit to the United States late in 1958, the Queen was an interested and knowledgeable visitor to several of the Commission's reactor and research facilities.

The Venezuelan research reactor was temporarily shut down on September 15, 1961, in order to afford additional training for the Venezuelan scientists and engineers associated with the reactor project. The United States contributed $350,000, in 1960, toward the construction of the Venezuelan 3 megawatt (thermal) swimming pool type reactor and leased approximately 5 kilograms of uranium enriched up to 20 percent in the isotope uranium 235 for use as fuel in the reactor.

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Grants of nuclear equipment valued at approximately $80,000 were approved for the following technical assistance programs to be administered through the International Atomic Energy Agency:

Argentina—An ion source to be used in the electromagnetic separation of isotopes, and an electron paramagnetic resonance spectrometer;

Brazil—Radioisotope equipment for use in agricultural research; and

Israel—Equipment for one mobile and two stationary area monitoring stations to be used at the 1 megawatt (thermal) swimming pool reactor at Nahal Sorek.

EQUIPMENT GRANTS

	1960	*1961* [a]
Atomic Energy Commission	$754, 416	-------
International Cooperation Administration	235, 000	-------
International Atomic Energy Agency [b]	192, 000	$80, 000
	1, 181, 416	80, 000

[a] As of December 31, 1961.
[b] Equipment in kind furnished through the IAEA.

Technical Cooperation

As a part of its technical cooperation program with other countries, the Commission encouraged visits by foreign specialists to its unclassified facilities and sent U.S. representatives abroad on a continuing basis. Additionally, it is making U.S. technical information available to other countries through the establishment of depository libraries in a growing number of countries.

VISITS

	1960	*1961*
Number of Foreign Visitors to AEC Facilities	1, 150	875 [a]
Number of AEC Representatives Visiting Aboard	381	978 [b]

DEPOSITORY LIBRARIES (Cumulative)

Total Number	84	87
Number of Countries	60	61
Number of International Organizations	5	5

[a] As of December 31, 1961.
[b] Approximate as of December 31, 1961.

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Exchange of Information

Some of the more significant cooperative ventures with other governments of mutual benefit to the atomic energy programs of both the United States and the cooperating country are summarized below.

United Kingdom. An active interchange of information on a broad scale continued with the United Kingdom, particularly in the fields of advanced gas-cooled reactor systems, fast reactors, feed materials, chemical processing, plutonium finishing, health and safety, effluent disposal, controlled thermonuclear research, and basic research in the physical sciences.

As a part of their training for the startup and operation of the Experimental Gas-Cooled Reactor at Oak Ridge, technical personnel from the Tennessee Valley Authority which will operate the reactor under contract to the Commission were assigned to the United Kingdom's Berkeley Nuclear Power Station for extended periods of time, including the start-up operation of the reactor. Exchanges of personnel for long-term assignments were arranged in the fast reactor research, chemistry and physics, and controlled thermonuclear fields.

An example of the many meetings held between U.S. and U.K. atomic energy scientists were the series of visits dealing with feed material processing, including treatment, and fabrication of unalloyed uranium metal. A U.K. team visited the Weldon Spring, Mo., facility in March 1961, followed by a U.S. team visit to Springfields and Harwell, England, in May. A third meeting was held in the U.K. during September. These exchanges of information have been mutually beneficial and additional meetings are anticipated in the future.

Australia. Agreement was reached with Australia for an exchange of information on high temperature gas-cooled reactors and related subjects. The agreement entails the exchange of reports and visits and long term exchanges of personnel.

Canada. United States-Canadian atomic energy cooperation was marked by a number of new developments during 1961, as well as improved exchange of technical information on natural uranium heavy water reactors. Canada purchased 169,500 pounds of heavy water, the largest single purchase of U.S. produced heavy water to date. Atomic Energy of Canada, Ltd. stationed two scientists in the United States, one at the site of the heavy water component test reactor and the other at Atomics International, where a considerable amount of the Commission's organic reactor developmental work is underway. In return, the United States has several scientists stationed at Canadian installations.

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As a part of the United States-Canadian heavy water reactor co-erative development program, the Savannah River Operations Office rarded a contract to AMF Atomics for developing a fueling machine r the Canadian natural uranium, heavy water moderated and cooled, wer reactor (CANDU). Considerable progress has been made in eliminary design work for the device, and testing of key com-nents was begun in June, 1961. The AMF machine will serve as back-up to the one Canada will install in their CANDU project.

Because of United States interest in the CANDU reactor program, e Commission agreed in principle to perform test radiations of ANDU fuel elements in the heavy water components test reactor HWCTR) at Savannah River, S.C., with preliminary work begin-ng in July, 1962.

A total of 13 new projects, all of which will be carried out in the nited States with expenditures amounting to $411,000, were ap-oved by the technical advisory committee for the United States-anadian heavy water cooperative program. This brings total U.S. mmitments to $1,600,000.

Action was also started, since Canada and the United States each ve separate cooperative agreements with Euratom, to execute a operative tripartite agreement on heavy water reactor technology rolving the United States, Canada, and Euratom.

Following their offer of assistance to the Commission in connection th the January 1961 SL–1 reactor accident at the National Reactor sting Station, Idaho Falls, AECL sent two men to the reactor site o had been closely associated with the clean-up work of the Decem-r 12, 1952 Canadian NRX reactor accident.

Hanford also has three projects for AECL under the Commission-ECL Cooperative Program. They include: (1) development of n-destructive testing methods and integrated equipment for ac-tance testing of thin-walled fuel sheath tubing; (2) heat transfer d fluid flow studies on proposed fuel element types; and (3) dem-stration and evaluation of the application of magnetic force weld-g proposed for cladding for an Organic Cooled Reactor Experiment.

pan-U.S. Atomic Industrial Forum Meeting. The second United tes-Japan Atomic Industrial Forum Conference was held in Tokyo ring December. Major objectives of the meeting were (1) to ex-ange information of the current status and future prospects for elopment of power reactor technology; (2) to increase mutual derstanding between the nuclear industries of the two nations; and to discuss policies for U.S.-Japanese cooperation on both govern-ntal and non-governmental levels. Commissioner Robert E. Wilson ded the United States representation and presented to the Confer-e the aims and objectives of the U.S. atomic energy program.

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DRAGON High Temperature Reactor Project. In February, a further Collaboration Agreement was reached between the Atomic Energy Commission and the *DRAGON* Project on exchanges of staff for extended periods. The DRAGON Project is a joint undertaking of the United Kingdom Atomic Energy Authority and other members of the European Nuclear Energy Agency of the Organization for Economic Cooperation and Development for construction of an experimental 20 megawatt, thermal, high temperature gas-cooled reactor at Winfrith Heath, England.

The United States has furnished computer codes for use by the Project, and results of experiments in ZENITH (a graphite moderated research reactor) and the General Atomic Critical Experiment Facility in San Diego have been interchanged. In the latter exchange, samples have been interchanged for irradiation and compatibility studies. There have also been exchanges of information on graphite production and fuel element work.

U.S.—DRAGON PERSONNEL EXCHANGE

	1960	1961
Number of U.S. visitors to United Kingdom	15	14
Number of United Kingdom visitors to United States	13	19

Eurochemic Company. The United States continued its cooperation with Eurochemic (European Company for Chemical Processing of Irradiated Fuels), a semi-private international share-holding company with members from 13 Western European countries. Construction of Eurochemic's chemical processing facility at Mol, Belgium, was scheduled to begin in late 1961, with completion planned for the second half of 1963. More than 200 U.S. documents relating to chemical reprocessing were sent to Eurochemic during 1961 and the Atomic Energy Commission continued the assignment of a full-time technical adviser in residence at Mol.

Consultants and Research Contracts

Cost Free Consultants

Through arrangements with the IAEA, the United States made available, without charge, nine atomic energy consultants to Pakistan, the Philippines, Israel, Japan, Indonesia, and the Republic of China. These individuals, whose assignments range from two weeks to three months, provided assistance on such projects as planning for training courses in radioisotopes in conjunction with the IAEA mobile laboratory,[23] and assisting in reactor hazards evaluation work.

[23] See p. 206, Annual Report to Congress (January–December 1960); p. 17, Twenty-fourth Semiannual Report to Congress (January–July 1958).

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US-IAEA Research Contracts

During 1961, the Commission placed research contracts with IAEA totaling $117,200 for work in institutes in Venezuela, Austria, Finland, England, Australia, and Norway. All of these projects, with the exception of the NORA Project in Norway, dealt with studies in the fields of biology and medicine. In addition, there were four renewals of research contracts totaling $40,080.

IAEA ASSISTANCE [a]

	1960	1961
Number of U.S. cost-free consultants [b]	5	9
Number of countries served [c]	4	7
Approximate cost to U.S.	$16,087	$30,894
Total number of Technical Assistance experts on assignment [d]	37	55
Number of U.S. Technical Assistance experts on assignment	11	19
Number of research contracts financed by U.S. through IAEA	14	[e] 6
Amount committed to joint US–IAEA research contract program	$145,314	$157,280
Value of U.S.-equipment grants to IAEA	$192,000	$80,000

[a] As of December 18, 1961.
[b] Assignments usually one month or less.
[c] In 1960—Morocco, Korea, Taiwan and IAEA Headquarters in Vienna. In 1961—Pakistan, Philippines, Japan, Taiwan, Israel, Indonesia and IAEA Headquarters in Vienna.
[d] Assigned to Member States on IAEA technical assistance projects which have been implemented as a result of recommendations made by preliminary assistance missions. Assignments vary in duration, but most last from six to twelve months.
[e] Plus four contract renewals.

IAEA FELLOWSHIPS

	Through 1960	1961 [a]	Total
Number of Type I [b] Fellowship Students Trained in U.S.	41	30	71
Number of Type II [c] Fellowship Students Trained in U.S.	176	58	234

[a] As of November 30, 1961.
[b] Type I Fellowships are those financed by an appropriation from the IAEA General Fund.
[c] Type II Fellowships are those financed by the host country.

U.S. CONTRIBUTIONS TO IAEA BUDGET

	1960	1961
Regular Budget (Assessed)	$5,843,000	$6,168,000
International Budget (Voluntary contributions pledged)	996,103	1,259,444

Education and Training

The Atomic Energy Commission's international training program during 1961 continued the trend toward fostering advanced work and independent research by a greater proportion of foreign participants.

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The increasing number of basic nuclear science and engineering courses being offered by colleges and universities and the need for more highly trained personnel to carry on the activities of expanding atomic energy programs in other countries account for this emphasis.

The Atomic Energy Commission's principal training centers—the International Institute for Nuclear Science and Engineering at Argonne National Laboratory, the Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies (ORINS), and the Puerto Rico Nuclear Center—offer foreign students a broad field from which to select the particular training which will best serve the peaceful atomic energy needs of their country.

An increasingly large proportion of the groups attending Argonne's International Institute are being assigned as Affiliates. The Affiliate appointment for which there is no tuition fee, is open only to post-doctoral candidates who have had three to five years experience beyond that expected of Institute students. Based on their prior training, experience and specialized interests, Affiliates begin individual research projects shortly after arrival at the Institute.

The research projects of Affiliates may extend from one to two years, benefiting not only the individual and his country's atomic energy efforts, but also contributing toward the development of new knowledge of interest to the United States' atomic energy program. Research opportunities are also available at the Puerto Rico Nuclear Center and the national laboratories which accept qualified foreign scientists as guests for advanced research. The areas of greatest participation of foreign students are in reactor technology and the ORINS course on techniques for using radioisotopes.

The number of foreign students participating in formal training at Commission-sponsored courses during 1960 and 1961 (as of November 30, 1961) were:

	1960	1961
Oak Ridge Institute of Nuclear Studies	61	[illegible]
International Institute of Nuclear Science and Engineering (Argonne National Laboratory)	109	[illegible]
Puerto Rican Nuclear Center	37	[illegible]
All other facilities	75	[illegible]

The number of foreign guests participating in individual training assignments at Commission contractor-operated installations during the past two years were:

	1960	1961[a]
Brookhaven National Laboratory	85	[illegible]
Oak Ridge National Laboratory	101	[illegible]
Argonne National Laboratory	60	[illegible]
Lawrence Radiation Laboratory (Berkeley)	91	[illegible]
All other facilities	65	[illegible]

[a] As of November 30, 1961.

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International Conferences

International Scientific Conferences

The Commission gave financial support to the following conferences which were sponsored by U.S. scientific organizations and conducted both in and outside the continental limits of the United States. These conferences were:

"Conference on the Use of Animal Cell, Tissue and Organ Cultures in Radiobiology," New York, February 16–18. Total Attendance, 50.

"International Symposium on Statistical Genetics and Plant Breeding," Raleigh, North Carolina, March 20–24. Total Attendance, 30.

"Symposium on Chemical Reactions in the Lower and Upper Atmosphere," San Francisco, Calif., April 18–20. Total Attendance, 300.

"International Symposium on Some Aspects of Internal Irradiation," Homestead, Utah, May 10–12. Total Attendance, 125.

"International Symposium on Quantitative Biology, Cell Regulatory Mechanisms," Cold Spring Harbor, New York, June 4–12. Total Attendance, 50.

"International Congress of Biophysics," Stockholm, Sweden, July 31–Aug. 4. Total Attendance, 1,000.

"Fifth International Congress of Biochemistry," Moscow, USSR, Aug. 10–16. Total Attendance, 3,000.

"Tenth Pacific Science Congress," Honolulu, Hawaii, Aug. 21–Sept. 6. Total Attendance, 1,200.

"International Conference on Chemical Physics of Non-Metallic Crystals," Evanston, Ill., Aug. 28–31. Total Attendance, 50.

"Symposium on the Effects of Ionizing Irradiations on Immune Processes," Lawrence, Kansas, Sept. 6–8. Total Attendance, 300.

"Third International Conference on High Energy Accelerators," New York City and Brookhaven National Laboratory, Sept. 6–12. Total Attendance, 200.

"Conference on Electromagnetic Lifetimes and Properties of Nuclear States," Gatlinburg, Tenn., Oct. 5–7. Total Attendance, 100.

"International Conference on Radiation-Induced Chromosome Aberrations," San Juan, Puerto Rico, Nov. 16–18. Total Attendance, 55.

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IAEA conferences. The Commission coordinated participation in nine International Atomic Energy Agency conferences and symposia, all of which were held outside the continental United States. Of the 321 United States participants, 125 attended at Commission expense while 196 had their way paid by their employers or the IAEA.

IAEA CONFERENCES

Title, place, and dates	Total attendance	No. of U.S. participants	No. at AEC expense
"Symposium on the Detection and Use of Tritium in the Physical and Biological Sciences," Vienna, Austria, May 3–10	500	34	[illegible]
"Conference on Nuclear Electronics," Belgrade, Yugoslavia, May 3–10	700	29	[illegible]
"Symposium on the Effects of Ionizing Radiation on the Nervous System," Vienna, Austria, June 5–9	150	11	[illegible]
"Symposium on Whole Body Counting," Vienna, Austria, June 12–16	125	15	[illegible]
"Conference on the Physics of Fast and Intermediate Reactors," Vienna, Austria, Aug. 3–11	170	23	[illegible]
"Conference on Plasma Physics and Controlled Nuclear Fusion Research," Salzburg, Austria, Sept. 4–9	600	130	[illegible]
"Symposium on the Programming and Utilization of Research Reactors," Vienna, Austria, Oct. 16–20	175	35	[illegible]
"Symposium on Power Reactor Experiments," Vienna, Austria, Oct. 23–27	100	9	[illegible]
"Conference on the Use of Radioisotopes in Animal Biology and the Medical Sciences," Mexico City, Mexico, Nov. 21–Dec. 1	300	35	[illegible]

The Commission also supported travel costs of U.S. delegates to several international conferences held abroad but sponsored by groups other than the IAEA. These included the Symposium on Criticality Control, Karlsruhe, Germany (approximately 150 total attendance); the Fourth Japan Conference on Radioisotopes, Kyoto, Japan (approximately 400 total attendance); and the Eighth Nuclear Congress, Rome, Italy (approximately 200 total attendance). Selected U.S. participants presented scientific and technical papers at these meetings.

INTERNATIONAL NUCLEAR ENERGY EXHIBITS

Latin American Exhibit

The Commission's large "Atoms at Work" exhibit continued to draw enthusiastic response during its 1961 tour of South America. The exhibit, which is housed in a unique, air-supported transportable structure was first shown in Buenos Aires, Argentina, during November–December 1960. During 1961, it was presented for a month at both Rio de Janeiro, Brazil, and Lima, Peru. It is scheduled to be shown in Mexico City, Mexico, in April 1962, and in Santiago, Chile, in November, and tentatively in Bogotá, Colombia, in April 1963.

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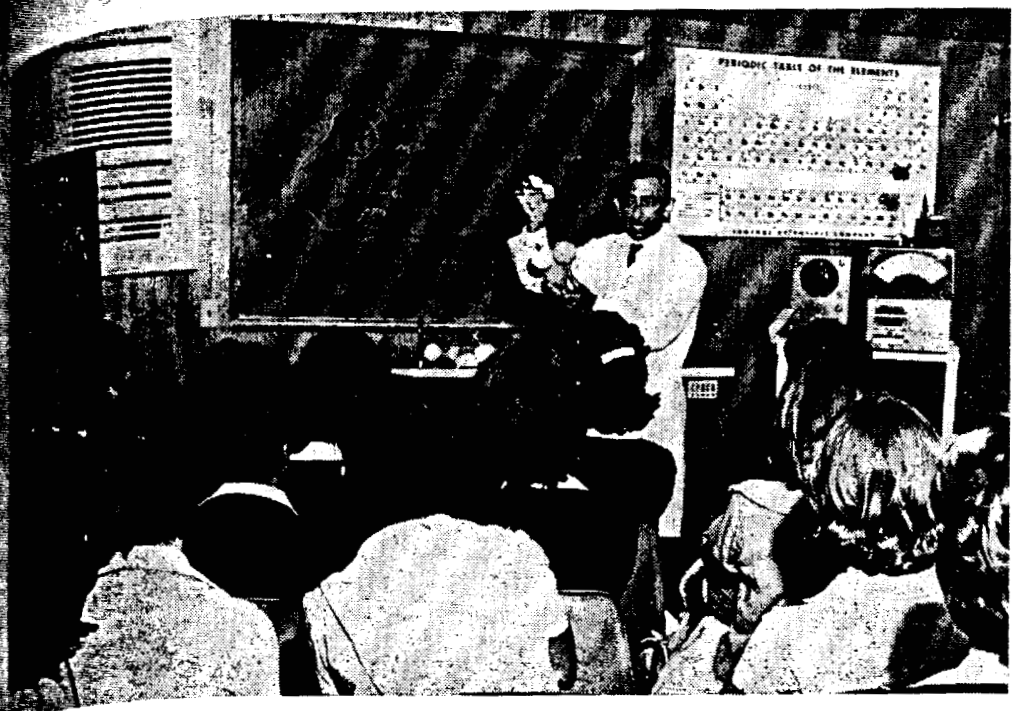

Classroom. One of the features of the Commission's "Atoms at Work" which toured South America during 1960 and 1961 were the special room sessions. Photo, taken during the Rio de Janeiro showing of the (see page 21 for exterior photo), shows Brazilian students receiving three of instruction and demonstration on the fundamentals of nuclear energy the air-conditioned classroom-laboratory of the exhibit. Specially trained ilian teachers did the instructing. During the 33-day stand of the exhibit Rio, 70 schools scheduled groups of their science students to receive this of instruction. Over 4,300 students participated in this program.

de Janeiro Showing

The attendance of over 200,000 people indicates the Brazilian pub- response to the May–June showing of the "Atoms at Work" ex- . The intense interest in the subject matter by Brazilian students evidenced by the attendance of 20,000 students from Rio de eiro and neighboring Brazilian states who visited the exhibit in anized scheduled groups. In addition, over 4,300 high school ents from 75 different schools participated in the science lecture- onstration program which was conducted in a classroom in the ibit. These students were given three hours of instruction on the damentals of atomic energy by Brazilian high school teachers who been specially trained by instructors from the Oak Ridge Insti- of Nuclear Studies (ORINS). Three 3-hour periods were sched- every day of exhibit operation. This program received enthusias- endorsement and support from the Minister of Education of Brazil from the Secretary of Education for the state of Guanabara de Janeiro). An ORINS-trained Brazilian and a two-man team the Oak Ridge Institute of Nuclear Studies was in charge of program. 5007388

Other indications of the public's interest in the exhibit were the organized visits of various work, civic, and service groups. The Gillette Safety Razor Company closed its factory for one-half day and brought its entire force of 350 employees to the exhibit in eight chartered buses. Other organized groups included employees from the Esso Oil Co. of Brazil, Kibon Dairy Co., the Fire Department of Rio de Janeiro and 500 Brazilian Naval Academy cadets.

The enthusiastic response of the Brazilian scientific community was seen in the oversubscribed participation in the reactor and gamma facility demonstration programs. The reactor demonstration program was coordinated by an American scientist from the Battelle Memorial Institute, and a Brazilian Nuclear Energy Commission scientist. The demonstration was conducted to provide opportunity for technically trained and interested persons to participate at their level of training and experience in programs utilizing a 10 kw reactor and its associated equipment. The reactor used in Rio de Janeiro was a pool-type training and research reactor manufactured by Lockheed Nuclear Products. The program had three levels of participation:

(*a*) *Reactor experimental program* of 17 planned experiments which required 100 hours to complete. Seventy-six students registered to take all 17 experiments, and 15 other students participated in selected experiments.

(*b*) *Reactor orientation program* consisting of four hours which included a short lecture, a film about reactor technology, and a tour of the reactor facility. Four hundred persons were enrolled in this course.

(*c*) *A tour and explanation of the reactor facility* was conducted for over 1,200 interested persons. Of this number, 500 were cadets of the Brazilian Naval Academy.

An experimental program was conducted in connection with the tank-type gamma facility, designed and fabricated for the exhibit by Brookhaven National Laboratory. The facility, which has an irradiation source of 2,000 curies of cobalt 60 was used to irradiate samples for twenty institutions from Rio de Janeiro, Sao Paulo, Belo Horizonte, Minas Gerais, and Bahia. In addition to performing experimental irradiations, Brazilian scientists studied gamma facility techniques in a training program conducted by the American staff. Scheduled groups of Brazilian University students, teachers, and other interested persons attended lectures by the staff on the physics of high energy radiation and radiation biology and chemistry.

A SNAP III generator was displayed during the last two weeks of the exhibit. A model airplane electric motor and propeller was connected to the SNAP device to demonstrate to the public that the generator produced electricity. The SNAP display elicited considerable interest from the general public. In addition to the display of

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device, the SNAP III safety film was shown to the public in the American Embassy theater on several occasions, and seminars were conducted in Rio, at the University of Brazil, Catholic University, and the National Engineering Institute, and at nuclear institutions in Sao Paulo and Belo Horizante.

The exhibit in Rio, as are all AEC international exhibits, was a cooperative undertaking between the United States Atomic Energy Commission and the Brazilian National Nuclear Energy Commission (Commissao Nacional Energia Nucleare).

All of the scientific and educational programs presented in the exhibit were coordinated jointly by American and Brazilian scientists.

RIO DE JANEIRO SHOWING STATISTICS

Total attendance	200,000
Student-classroom program attendees (from 75 schools)	4,300
Reactor experimental program participants	91
Lecture series attendees (high-energy radiation, radiation biology, radiation chemistry)	400
Private consultations on biological, chemical, and industrial applications of radiation	20
Technical information centers visitors	1,100
Technical film showings attendees	650
Press media coverage:	
Newspaper stories	160
Magazine (Brazilian) articles	6
Live television shows from exhibit [a]	2

[a] In addition, a large number of video tape shows were made, and considerable movie newsreel coverage was shown in Rio de Janeiro during construction and operation of the exhibit.

Lima Showing

Opening October 7, this exhibit was shown at Lima, Peru, in cooperation with the Atomic Energy Control Board of Peru (*Junta de Control de Energia Atomica*). Scientific and educational programs similar to those at Rio de Janeiro were conducted in connection with the Lima exhibit; scientists and students of several Latin American countries were invited to participate. University students and young scientists from the host country served as guides and lecture-demonstrators. Attendance totaled 76,431, including students, teachers, and scientists who participated in the exhibit lecture and research programs indicated below. These programs, as at past exhibits, were conducted in cooperation with host country scientists, technicians, and educators.

Reactor Demonstration Program: 800 scientific personnel attended lectures and seminars on the functions and operation of a nuclear reactor, centered around a 10 kw research and training

reactor leased from and manned by Lockheed Nuclear Products. Critical experiments held during the afternoons were followed by evening seminars. The reactor program aroused an outstanding degree of interest; over 2,300 persons, in addition to the scientists attending the seminars, received general orientation and toured the facility. The reactor was used to produce a small number of short-lived radioisotopes during the course of the exhibit.

(*b*) *Gamma Facility Program:* 810 samples were irradiated by the cobalt 60 source in the gamma facility, which was fabricated and staffed by scientists from Brookhaven National Laboratory. The American scientists held 190 individual conferences with Peruvian scientists interested in the uses and operation of the facility, and conducted seminars for 850 professionals. During the first week of the exhibit, requests for irradiation of seeds, plastics, legumes, and other materials resulted in 120 individual irradiations involving several levels.

(*c*) *Student-Teacher Lecture Demonstration Program:* This program at Lima, as in the previous Latin American exhibit showings, won highly enthusiastic support from local high school students and Peruvian educators. A scientist representing the Oak Ridge Institute of Nuclear Studies, which planned and coordinated the program, lectured to 440 Peruvian high school science teachers and 4,025 students on the fundamentals of atomic energy.

(*d*) *Technical Information Center:* The Technical Information Center, where unclassified materials at varying levels of difficulty were available, was well utilized by the Peruvian scientific community. About 2,000 persons viewed atomic energy films at the small motion picture theater in the Center. In addition, members of the exhibit staff presented lectures to approximately 1,500 persons at two hospitals and two colleges in the Lima area.

Member firms of the nuclear industry loaned models and operating equipment for inclusion in the Latin American exhibit; products of 22 firms were displayed at Lima. A mechanical manipulator was used to illustrate how radioactive materials are safely handled and a reactor simulator was used in conjunction with the operating reactor demonstration program to teach reactor theory and operation.

Beirut exhibit

The Middle Eastern "Atoms at Work" exhibit was conducted at Beirut, Lebanon, for four weeks beginning October 8, in cooperation with the Lebanese Atomic Energy Committee. Over 67,000 people, representing about 13 percent of Beirut's population, attended this

exhibit which was previously shown in Cairo, Egypt (May 8–June 9, 1960) and Lahore, Pakistan (November 6–December 2, 1960).

The exhibit was composed of over 30 displays including an operating L-77 research and training reactor leased from Atomics International, and a pool-type gamma irradiation facility designed and fabricated for the exhibit by the Brookhaven National Laboratory. Graphics, panels, photographic and animated displays and working models supplemented the operating nuclear equipment to dramatize the progress achieved in applying atomic energy to these major areas:

1. *Nuclear Power Production.*—A power reactor model, a model of the NS *Savannah*, and an animated sequence illustrated the production of power by a nuclear reactor.

2. *Industry.*—This display demonstrated the use of radioisotopes for gauging the thickness of sheet materials, liquid levels gauging and industrial radiography.

3. *Agricultural Research.*—This section contained an explanation of the unique radiation sterilization technique used to eradicate the screw worm fly, which attacks cattle, from the Southeastern United States. Also demonstrated were examples of how new and better varieties of plants are being developed through seed irradiation, and uses of radiotracers in agricultural research.

4. *Medicine.*—Included was a scintillation scanner used to map the distribution of radioactive material inside the body.

A specially designed introductory film and distribution of literature at various technical levels supplemented the nuclear equipment. Lebanese educational institutions supplied guides and demonstrators to conduct tours of the exhibit for the general public.

In addition to the displays and demonstrations in the exhibit tour received by the general public, a scientific institute was held where the following programs were conducted jointly by American and Middle Eastern scientists:

(a) *Reactor Demonstration Program:* 515 students and 62 professional scientists and teachers participated in the program demonstrating an operating research and training reactor leased from Atomics International.

(b) *Gamma Facility Program:* Seminars and lectures, attended by approximately 800, were held in connection with the gamma irradiation facility fabricated and staffed by Brookhaven National Laboratory. Two hundred eighty-two samples were irradiated by the 2,400 curie cobalt-60 source contained in the facility.

(c) *Student-Teacher Lecture Demonstration Program:* The Student-Teacher Lecture Demonstration Program, coordinated by a representation of ORINS, was one of the best-received features of the exhibit. In a program similar to that held in connection with the Latin American exhibits, 112 lectures were given to 1,488 high

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school students and 115 teachers. Extra evening lectures were scheduled to meet additional requests for participation from public and private high schools in the area.

(*d*) *Technical Information Center:* Over 600 scientists visited the exhibit's Technical Information Center and used the library and technical film screening equipment.

Approximately 15 American industrial firms loaned nuclear equipment for inclusion in the project; much of the equipment was operated in connection with the training programs in the Scientific Institute.

BIOLOGY AND MEDICINE

The Commission's biology and medicine program covers a wide scope of research in scientific areas which underlie better understanding of the principles, mechanisms, and implications of the interactions of radiations with biological systems, and which provide data to extend and refine the existing scientific guidance for the control of exposure to radiation. The program also includes studies of specialized problems of health and safety in atomic energy operations and extension of beneficial applications of nuclear materials and atomic energy. These three broad categories of research consist of a number of individual sub-programs which are mutually dependent for scientific progress. The results of fundamental research and developmental work in these areas are described in a special Commission report supplementing this Annual Report to Congress.[24]

For research in the medical and biological fields—life sciences—the Commission expended $53 million for the fiscal year that ended June 30, 1961, for operating expenses. Some $35 million of this total was for research and operating expenses of Government-owned or financed laboratories operated for the Commission by universities or industrial organizations and some $18 million was for research in universities, colleges, and other institutions carried out under 611 research contracts. In addition, $4.7 million was obligated for construction projects related to the life sciences. This Annual Report to Congress describes selected major activities during the past year related to fallout, nuclear civil effects and studies of inhaled fission products. Results of basic research in life sciences at major Commission installations, universities, and colleges were described in the special report mentioned above.

[24] "Atomic Energy Research—Life and Physical Sciences, Reactor Development and Waste Management—1961", available from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.; also, "Atomic Energy Research in the Life and Physical Sciences—1960", available from the Superintendent of Documents, $1.25.

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TABLE 5.—AEC-SUP
RADIOACTIV

Type of sample	Sampling system
Upper air	Balloon
Upper air	Aircraft
Surface air	80th Meridian
Surface air	AEC sites
Surface air	Special
Deposition	Pot & funnel.
Deposition	Large-area
Deposition	Gummed film.
Soil	Soil
Milk	Sr-90
Milk	Cs-137
Diet	Tri-City
Diet	Consumers Union (CU).
Man	Bone
Man	Cs-137

*WB—U.S. Weather Bu
NRL—Naval Research I
AEC—Atomic Energy C
HASL—AEC Health an
Contr.—AEC Contractor
DA—Department of Agr
LASL—Los Alamos Scie
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FALLOUT STUDIES

Although responsibility for radiation surveillance and monitoring is assigned to the Department of Health, Education, and Welfare, several fallout sampling networks are operated for research purposes under partial or complete Commission sponsorship. These networks are shown in Table 5 as they were prior to Soviet resumption of nuclear weapons tests on September 1, 1961, and they have since been modified to obtain information on debris movement and deposition from those tests.

TABLE 5.—AEC-SUPPORTED SAMPLING NETWORKS FOR ATMOSPHERIC RADIOACTIVITY AND FALLOUT (Pre 9–1–61 and Post 9–1–61)

Type of sample	Sampling system	Scientific direction	Sample collection	Sample analysis	Number of locations		Samples per yr per station		Number of nuclides analyzed	
					Pre	Post	Pre	Post	Pre	Post
Upper air	Balloon	WB*	AF	AEC & Contr.	1	1	60	60	3+	9+
			Australia	do	1	1	60	60	3+	9+
			Gen Mills Inc.	do	1	1	12	36	3+	9+
Upper air	Aircraft	WB	AF	Various	4	4	60	60	8	8
Surface air	80th Meridian	NRL	NRL & Coop.	NRL	14	14	52	365	1	1
Surface air	AEC sites	AEC	Contr	Contr	10	10	6	12	5	9
Surface air	Special	Contr	Contr	Contr	1	2	365	365	1	1
Deposition	Pot & funnel.	HASL	Coop	HASL & Contr.	130	130	12	365	5	8
Deposition	Large-area	HASL & Contr.	Contr	Contr	7	7	6	12	1	2
Deposition	Gummed film.	HASL	Coop	HASL	0	50	50–150	50–150	2–5	3–8
[illegible]	Soil	DA	DA & HASL.	HASL	167 (**)		0	365	0	1
[illegible]	Sr-90	HASL	Coop	HASL	2	2	1 (**)		1–2 (**)	
[illegible]	Cs-137	LASL	LASL	LASL	16	16	12	12	1	2
[illegible]	Tri-City	HASL	HASL & Coop.	HASL	3	3	52	52	2	2
[illegible]	Consumers Union (CU).	CU	CU	CU	25	0	4	4	1	2
[illegible]	Bone	HASL	HASL & Coop.	HASL & Contr.	4	4	1	0	1+	0
[illegible]	Cs-137	LASL	LASL	LASL	variable		100	100	1	1
									2	2

*WB—U.S. Weather Bureau.
NRL—Naval Research Laboratory.
AEC—Atomic Energy Commission.
HASL—AEC Health and Safety Laboratory.
Contr.—AEC Contractor.
DA—Department of Agriculture.
LASL—Los Alamos Scientific Laboratory.
**The need for continuation of this program is under study.

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In general, the complete analysis of samples generated by these networks requires weeks or months. The resulting data, while not useful for rapid surveillance, do contribute to the assessment and prediction of longer-term exposures and as soon as they are obtained from the responsible scientists are reported to the Department of Health, Education, and Welfare, Public Health Service for publication in their monthly *Radiological Health Data*

These networks have provided much of the experimental evidence now available regarding the atmospheric residence time for nuclear weapons debris, and how this varies with the altitude, latitude, and yield of the detonation. In particular, unique radioactive isotopes of tungsten and rhodium have been used to identify Operation HARDTACK (test series in 1958 at Eniwetok Proving Ground and Nevada Test Site) surface-burst debris and ORANGE shot high-altitude debris respectively.[25]

Based on data from these programs and from other sources, an inventory and material balance of all the strontium-90 produced in tests prior to November 1958 have been estimated by U.S. Weather Bureau scientists. As of December 1960, the estimates are as follows:

ESTIMATED STRONTIUM 90 INVENTORY

(megacuries)

Total produced in tests prior to November 1958	9.2
Corrected for decay to December 1960	8.1
Less ⅓ local fallout	−2.7
Total available for worldwide fallout	5.4
Deposition based on mid-1959 soil measurements (corrected for decay to December 1960)	4.0
Deposition, mid-1959 to December 1960 based on pot and funnel measurements	0.7
Total worldwide deposition, December 1960	4.7
Stratospheric inventory based on aircraft and balloon measurements, December 1960	1.0
Total accounted for by air and ground measurements, December 1960	5.7

NOTE.—The estimated uncertainty in each of the above figures is at least 20 percent, so that the difference between the total available and the total accounted for is well within the error of measurement.

[25] Results of these studies and other aspects of the fallout studies program are reported in "Atomic Energy Research—Life and Physical Sciences, Reactor Development, and Waste Management—1961", available from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

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[27] See p. 183, Annual

NUCLEAR CIVIL EFFECTS

Bare Reactor Experiment (Nevada)—BREN

A 1,521-foot tower is under construction at the Nevada Test Site to support an unshielded reactor which will simulate emission of bomb neutrons and gamma radiation. Measurements of the radiation will be made to further the investigations of dosimetry data being obtained from the Japanese survivors of Hiroshima and Nagasaki in which the Commission's Oak Ridge National Laboratory, Los Alamos Scientific Laboratory, and the Atomic Bomb Casualty Commission [26] are engaged. This radiation dosimetry program for Japanese survivors seeks to relate the medical data of the survivors to the actual amount of radiation to which each person was specifically exposed.

Dose calculations for Hiroshima and Nagasaki contain large uncertainties at present. For Hiroshima, the uncertainty for the air dose has been of the order of ±200 percent for neutrons, and ±70 percent for gamma radiation. For Nagasaki, the uncertainties have been ±56 percent for neutrons, and ±64 percent for gamma radiation. Following the BREN experiments, the total uncertainties may be reduced to ±27 percent.

Regional Surveys

The Aerial Radiological Measurements and Survey (ARMS) Program used a new aerial radiometric system during the past year. The new system is designed for more rapid acquisition and reduction of the radiation data. Also, miniaturization of the instrumentation permits use of smaller aircraft. A Doppler radar navigational system has replaced the photographic method and total weight of the instruments has been reduced to about 650 pounds. Measurements of the radiation levels are electronically correlated with the space position of the aircraft and results are automatically recorded in-flight by a print-out system. The system has been calibrated with the U.S. Geological Survey radiation measuring equipment and equipment developed by other AEC sites in comparative flights made over the Extended Source Calibration Area at Nevada Test Site.[27]

The developer of the equipment, Edgerton, Germeshausen and Grier, a Commission prime contractor, has been assigned the responsi-

[26] The Atomic Bomb Casualty Commission of the U.S. National Academy of Sciences-National Research Council is sponsored by the Atomic Energy Commission. One of its purposes is to study the long-term effects of exposure to nuclear radiation. A summary of some of the effects noted among the Hiroshima and Nagasaki survivors is included in "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Management—1961."

[27] See p. 183, Annual Report to Congress for 1960.

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bility for management and scientific direction of this phase of the program which is called ARMS–II. The ARMS–II plane was engaged in proof-testing operational aerial surveys during the latter part of 1961.

FISSION PRODUCT INHALATION STUDIES

Construction is scheduled to start early in 1962 on facilities at Sandia Base that will be used in a fission product inhalation project which will study the biological consequences of inhaling fission products singly and as mixtures. The character and quantity of the radioactive aerosols inhaled by selected species of animals will be varied and quantitatively related to the amount of material initially deposited. By means of serial examinations of the experimental animals, the concentration of radioactive materials in the several body organs will be determined as a function of time to establish the temporal character of the radiologic and chemical challenge to the organism. Initial experiments will be carried out using tracer levels of selected fission products after which exposures sufficient to decrease the life span by ¾, ½ and ¼ and down to 30–60 days will be attempted. The patho-physiologic events which occur will be documented to the end that these may be quantitatively and etiologically related to the amount of material inhaled, excreted, translocated and "fixed" by biological processes.

The program will be conducted for the Commission by the Lovelace Foundation for Medical Education and Research in Albuquerque, N. Mex. An interim operating capability was established during 1961 and aerosol production and inhalation exposure of small animals were initiated using tracer-level doses employing space at the foundation headquarters and temporary housing at Sandia Base. A permanent facility to provide for aerosol production, high-level exposures of animals, and animal breeding and holding areas to be located on South Sandia Base has been planned. Architectural design will be completed by the end of 1961 and construction should begin in early 1962. Many of the more biomedically oriented studies, such as pathology, biochemistry, and microbiology will be continued at foundation headquarters and not transferred to the field facility mentioned above.

PHYSICAL RESEARCH

The Commission's physical research program includes investigations in the fields of physics and mathematics, chemistry, metallurgy and materials, and controlled thermonuclear research. Such investigations are undertaken for the purpose of discovering natural laws

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relevant to the Commission's responsibilities for the development, use, and control of nuclear energy. The atomic energy program of today owes its very existence to a few basic scientific discoveries and theories which can be traced to investigations similar to those conducted under the physical research program. Operating costs of this program in fiscal year 1961 totaled $154 million.

Results of some of the fundamental investigations conducted under the physical research program are described in a special Commission report supplemental to this Annual Report to Congress.[28] In this section of the regular Annual Report to Congress, the Commission summarizes the more important new physical research facilities in use during 1961 or now under construction, and a brief summary of the transplutonium element production program.

Costs incurred for the design and construction of research facilities for the Commission's physical research program totaled $47.5 million in fiscal year 1961. Of major importance to the program are the large particle accelerators which are essential in the high energy physics research area as a means of providing the fundamental information needed for the continued growth of atomic energy utilization. In recent years, scientists have identified some 30 different particles that make up the atom's core through the use of particle accelerators.

Research Facilities

Chemistry Annex

A new annex to the chemistry building at the Commission's Lawrence Radiation Laboratory on the campus of the University of California at Berkeley, Calif.,[29] was completed in July of 1961. This addition more than doubles the laboratory's present chemistry facilities. The enlarged facility will afford greater opportunities for research in radiochemistry and nuclear chemistry.

An inovation in the new chemistry annex is a low temperature laboratory. Although the study of radioactive atoms at extremely low temperatures is a relatively recent development it has already proven fruitful. For example, when radioactive nuclei are aligned, it is possible with the use of counters, to detect preferential directional patterns of radiations emanating from different nuclei. Such experiments can provide additional and important information on nuclear structure through determination of such properties as magnetic moments, spins, and angular momentum. Such information

[28] "Atomic Energy Research—Life and Physical Sciences, Reactor Development, and Waste Management—1961," available from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., also, "Atomic Energy Research in the Life and Physical Sciences—1960," available from Superintendent of Documents, $1.25.

[29] See footnote, p. 166.

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can be considered as increasing significantly our understanding of the nature and behavior of atomic nuclei.

The building cost is estimated at $2.15 million and will provide an additional 65,000 gross square feet of laboratory and experimental space.

Field-free Laboratory

A field-free laboratory building, designed to completely avoid any possible distorting magnetic influences, was also completed during the year at the Lawrence Radiation Laboratory (Berkeley). The laboratory is a single story, wood-frame, wood-sheathed building constructed of non-magnetic materials; the nails, for example, are aluminum. It cost less than $100,000 to construct and provides 2,400 usable square feet. Three separate laboratories are housed in this building. The nuclear spectroscopy laboratory, the atomic spectroscopy laboratory, and a laboratory concerned with radiochemical sources preparation associated with the nuclear spectroscopic research. It is situated far enough away from both the powerful magnetic fields of the laboratory's accelerators and from traffic to provide freedom from extraneous magnetic influences. Such arrangements are essential for accurate observation of beta ray spectra of radioactive nuclei.

The new building will make possible energy measurements of the very low energy beta rays emanating from radioactive nuclei. These measurements are of such a delicate nature that the smallest fluctuation of the magnetic field can cause distortion; in fact, scientists must even compensate for the weak magnetic field of the earth. The field-free laboratory will enable scientists to conduct extremely delicate and sensitive experiments that previously could not be carried out under ordinary laboratory conditions.

High Flux Isotope Reactor

The High Flux Isotope Reactor (HFIR) is now under construction at Oak Ridge National Laboratory. Gram quantities of californium and other transuranium elements will be produced by irradiating plutonium in a neutron flux of 3×10^{15}. This will be the world's most intense neutron flux, some ten times higher than that of the Materials Testing Reactor. The reactor is scheduled for completion in 1964.

There are, at present, no facilities for handling milligram quantities of the heavier transuranium elements inasmuch as these elements are highly radioactive—some of them emitting copious quantities of

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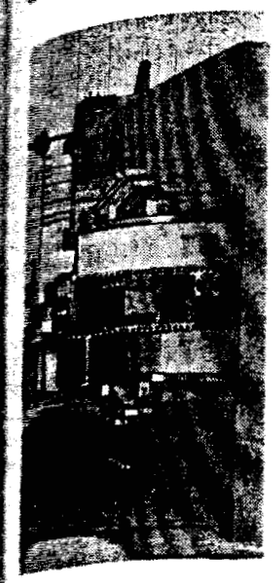

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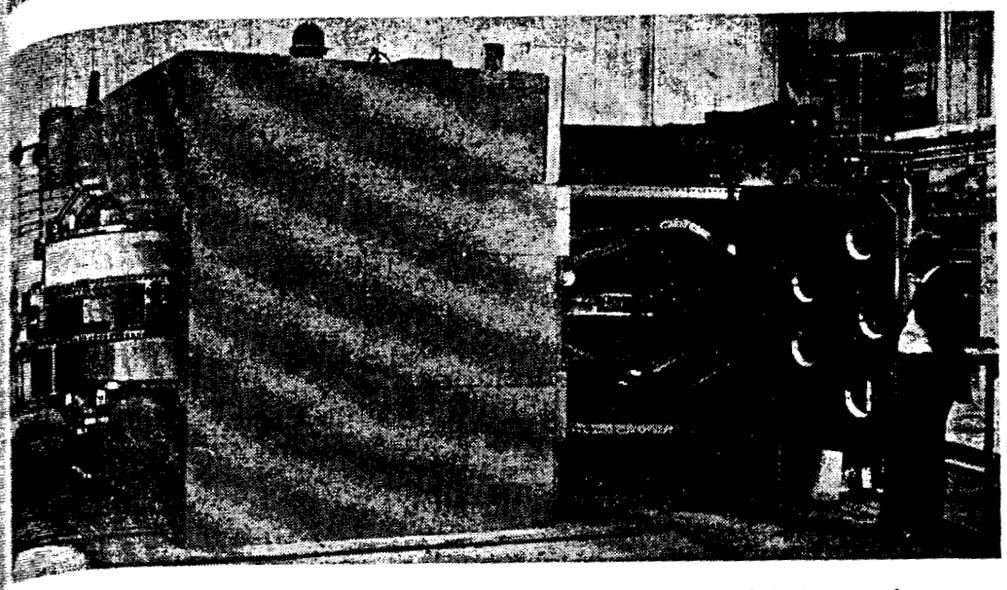
neutrons by spontaneous fission. The transuranium (TRU) facility, now being designed at ORNL, will permit mechanical and chemical operations on transuranium elements behind 4½ feet high density concrete walls. It is expected that TRU will cost about 8 million dollars and is scheduled for completion in 1965.



88-inch Cyclotron. Photo shows the new 88-inch cyclotron which is nearing completion at the Commission's Lawrence Radiation Laboratory (Berkeley). The new machine features a spiral ridge design (on the surface of magnets) to control the shape of the magnetic field, and which will permit better control of atomic particles at high energies. This will overcome some of the energy limitations of other types of cyclotrons.

88-inch Cyclotron

The 88-inch cyclotron accelerator at the Lawrence Radiation Laboratory, Berkeley, was 97 percent complete at the close of 1961. Built at a cost of $4.6 million, this facility is expected to be in operation in early 1962. Key features of the new accelerator will be its versatility in the medium energy field and its very high beam intensity of some million billion particles per second, about double that of the 60-inch cyclotron and 1,000 times greater than the 184-inch synchrocyclotron. Fabrication of the accelerator started in March 1959.

The new cyclotron is designed so that spiral ridges radiate from the center of each of the two pole faces of its magnet. The spiral ridge design will provide for variations in the magnetic field which will permit control of particles at relatively high energies, thus overcoming certain energy limitations of other types of cyclotrons.

This 88-inch machine will be able to accelerate alpha particles to a maximum of 120 million electron volts (Mev), deuterons to 60 Mev,

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and protons to 50 Mev. Heavy ions will be accelerated to between 10 and 15 Mev per nucleon. The peak energy of the machine will be almost three times that of the Lawrence Radiation Laboratory's 60-inch cyclotron, and the energy can be adjusted over a wide range which includes the energy levels obtained by the 60-inch accelerator.

Other research with the machine will include work on nuclear spectroscopy, nuclear reactions, and nuclear scattering. The intense beam of the 88-inch cyclotron will permit production of larger quantities of important isotopes of the very heavy elements, which will result in more detailed studies of the properties of the transuranium elements.

Accelerator Models

Fixed-field alternating gradient accelerators. The 40 Mev model of the Fixed-Field Alternating Gradient Accelerator (FFAG), which was designed, constructed and operated by the Midwestern University Research Association (MURA) Madison, Wis., attained an energy of 50 Mev and an intensity of 5×10^{12} electrons per second.

This accelerator was developed to prove the principles of FFAG beam stacking, two-way operation, and the feasibility of obtaining high intensity.

Beam stacking consists of successively accelerating pulses of electrons or other atomic particles in a fixed magnetic field and gathering them at a high energy to obtain a very large circulating current. Preliminary experiments in stacking have been successful. Two-way operation was achieved early in 1960, when beams were accelerated simultaneously in opposite directions around the accelerator. This was the first time such a feat has ever been accomplished.

The successful operation of the 40 Mev accelerator model has further strengthened the feasibility of obtaining high intensities and beam stacking with an FFAG accelerator.

ORNL Tandem Accelerator. An addition to the high voltage laboratory at the Oak Ridge National Laboratory has been built to house a 10-Mev Tandem Accelerator. The accelerator is installed and has produced a beam of several microamperes at 11 Mev. The first experiment utilizing an analyzed beam from the new accelerator was scheduled to start in December of 1961.

Cyclotron Analogue II. In August 1961, the Cyclotron Analogue II at Oak Ridge National Laboratory went into operation for the first time and the full design energy of 450 Kev was readily achieved. The Analogue is an electron cyclotron which models the magnetic field of a fixed frequency proton cyclotron to operate at about 850

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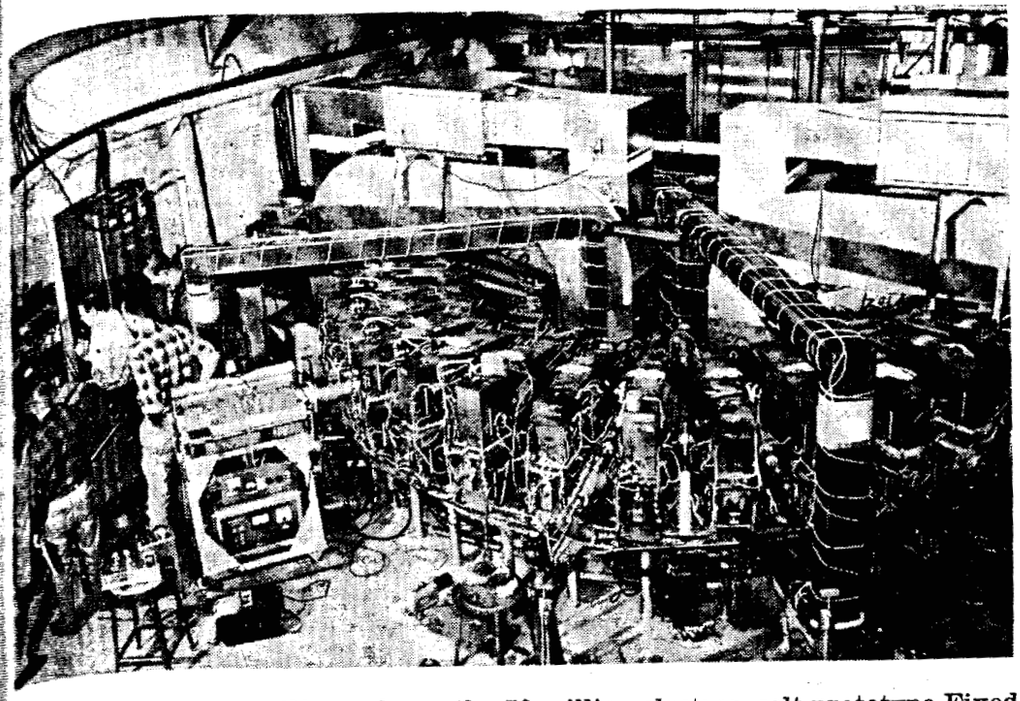

Prototype Accelerator. Photo shows the 50 million electron volt prototype Fixed Field Alternating Gradient Accelerator (FFAG) built at Madison, Wis., by Midwest Universities Research Association as a part of that group's studies on an accelerator of a radically different design. For the first time in history, the prototype accelerator made it possible to accelerate particle beams simultaneously in opposite directions within the same radio-frequency cavity. The photo was taken before the accelerator was disassembled for modifications of the magnetic field, subsequent to proving the feasibility of simultaneous, two-way operation of particle beams.

Mev. At this energy the effective mass of the high velocity particles is nearly doubled.

Achievement of such relativistic energies with constant frequency (isochronous) acceleration requires that the average magnetic field increases with radius. The average field at the maximum radius of the Analogue is about twice the central field. Marked azimuthal variations designed into the magnetic field provide the necessary forces to keep the ions focused toward the median plane.

The success of earlier tests on the Cyclotron Analogue I, which provided constant orbit frequency at the medium energy range, gave strong support for the design of the new isochronous cyclotrons, such as the Oak Ridge Isochronous Cyclotron (ORIC), now under construction and described below.

The successful operation of Analogue II strengthens the belief that a proton cyclotron in the 800–1,000 Mev energy range can be designed and constructed. The isochronous cyclotron is the only approach to high-current high-energy acceleration which promises the advantages of a continuous beam rather than a pulsed output.

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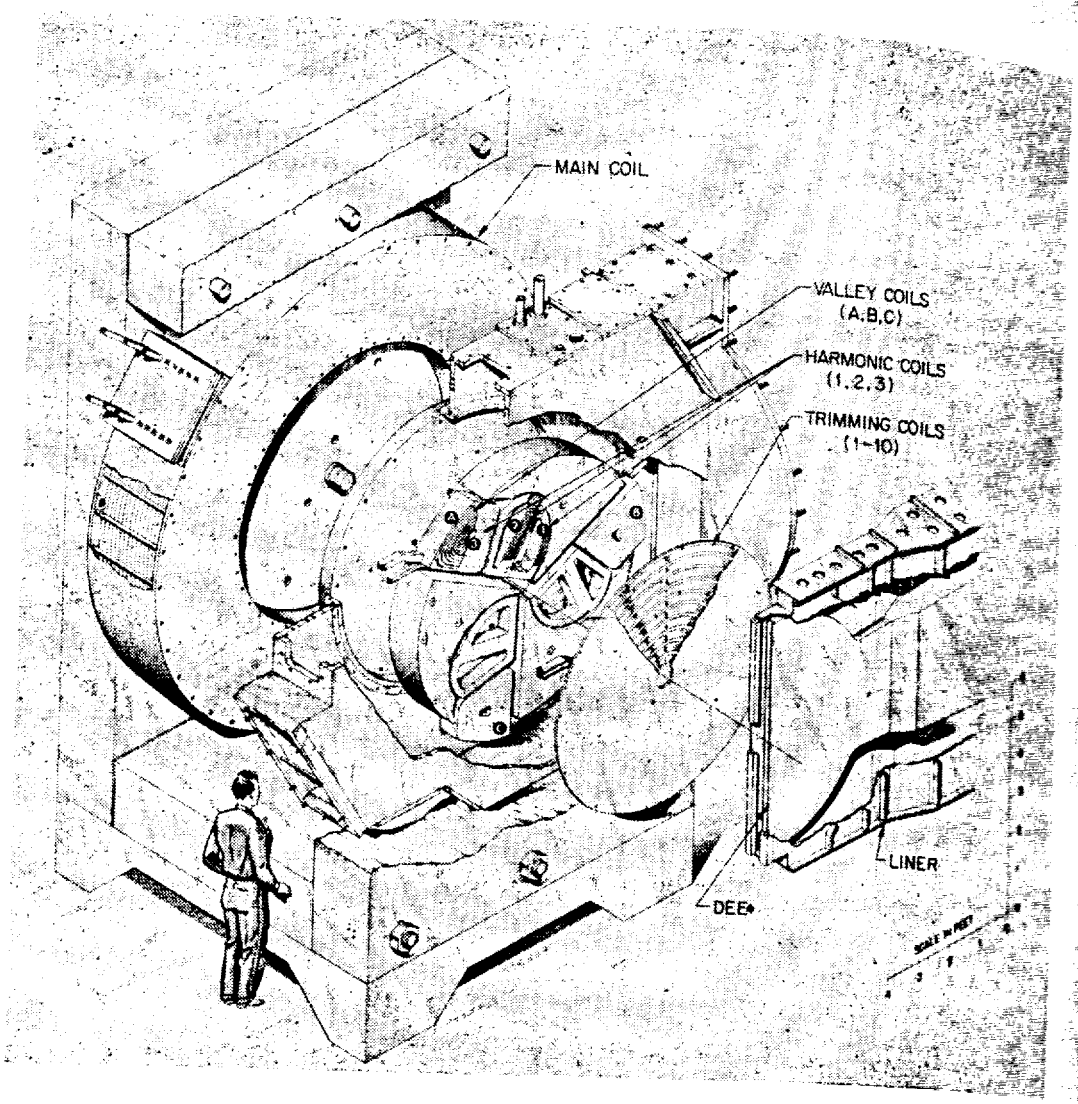

Complex Magnet. The magnet for the Oak Ridge Isochronous Cyclotron (ORIC) illustrates the complexity of the magnetic field in the new generation of isochronous cyclotrons. The focusing forces in ORIC are produced by a three-sector magnetic field configuration; the three "hills" and three "valleys" create pronounced azimuthal variations in field strength. The overall field is produced by the main coils. The azimuthal variations are obtained with sectored pole tips and by powerful valley coils; further adjustments are made with harmonic coils in the valleys. Currents in the ten pairs of trimming coils are used to increase the field radially to maintain constant orbit frequency (isochronism). A total of 21 separate magnet coil circuits, each with its well-regulated power supply, are used to produce and to shape the magnetic field to permit acceleration of various ions to a wide range of energies.

Oak Ridge Isochronous Cyclotron (ORIC)

The new building for the isochronous cyclotron at Oak Ridge National Laboratory was completed early in the year and the fabrication and installation of the cyclotron components approached completion by the end of 1961. *ORIC* is designed to extend the advantages of

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fixed-frequency cyclotron operation in accelerating protons at energies up to 75 Mev, deuterons at energies up to 40 Mev, alpha particles at energies up to 80 Mev, and several species of heavy ions at energies up to 145 Mev. In anticipation of very large beam currents, the cyclotron and experimental equipment are installed within a massive concrete shield about eight feet thick.

In ORIC, maintenance of a constant orbit frequency (isochronism) is made possible by designing the average magnetic field to increase with radius. The beam is constrained to motion in the median plane by magnetic-lens effects produced by a three-fold azimuthal variation of the field. Twenty pairs of specially designed coils mounted on and between, the pole tip sectors can be individually energized to shape the magnetic field so as to accommodate a wide range of ion types and energies. The radio frequency of the accelerating system can be varied to maintain resonance.

It is expected that test operation of this $3.7 million research facility will begin during the first quarter of 1962. Shortly thereafter, the versatile accelerator should be available for application to a wide range of necessary nuclear research problems.

Accelerators under Construction

Two of the three multi-Bev (billion electron volt) synchrotrons currently under construction were being finished during 1961. Both the *Cambridge Electron Accelerator* (CEA), a 6 Bev electron synchrotron, located at Cambridge, Mass., is expected to be in operation early in 1962. The *Princeton-Pennsylvania Proton Accelerator* (PPA), located at Princeton University is expected to be in operation by mid-year of 1962.

Construction of the *Zero Gradient Synchrotron* (ZGS) at Argonne National Laboratory, has been slowed due to difficulties with the fabrication of the ring magnet blocks. The balance of the project is proceeding on a satisfactory schedule, but the delay of this major component of the ZGS will extend the completion date of the project, which had been scheduled for mid-1962. The difficulties are under study. MURA has started building the 30-inch bubble chamber which will be used at the ZGS. This chamber should be ready for operation sometime in 1962.

Alternating Gradient Synchrotron

During the past year the beam intensities of the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory,[30] have

[30] See pp. 157–171, Annual Report to Congress (January–December 1960).

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been increased significantly. Early in 1961, the AGS had beam intensities averaging 5×10^{10} protons per pulse at energies in the neighborhood of 30 Bev. By September, 1961, the beam intensities had been increased to an average of 3×10^{11} protons per pulse at energies in the neighborhood of 30 Bev. Also, energies in the range of 33 Bev have been achieved. This increase in intensity affords greater opportunities to obtain meaningful data more effectively. At the normal operating energy of 30 Bev, the machine can deliver a pulse every 2.4 seconds. The pulse rate can be increased to 1.6 seconds at 20 Bev and 0.8 second at 10 Bev.

Stanford University Accelerator Project

In September 1961, Congress authorized the construction of the two-mile linear electron accelerator at Stanford University near Palo Alto, Calif. Initially, this accelerator will operate in the 10–20 Bev range. Actual construction is scheduled to start early in 1962 and will take approximately six years to complete. It will cost approximately $114 million when completed.

In addition to authorizing the full $114 million project which will be established as a national research facility, Congress appropriated $26 million for beginning construction, and $4.5 million to continue research and development work during the first year of construction. The Commission's San Francisco Operations Office established an Area Office near the site to administer the project.

The accelerator, when completed, will be the world's largest electron accelerator. It will be located on a 430-acre site and manned by about 750 scientists and technicians.

The accelerator will be installed underground by cut-and-cover methods. The site, including space for the end station, is about 2½ miles long. A minimum earth shield of 35 feet will be provided. As now planned, the accelerator will be powered by microwaves furnished by 240 klystron tubes. The pulsed wave output from each tube is being designed to be synchronized with the others so that electrons are accelerated along the pipe to nearly the speed of light (186,000 miles per second).

The purpose of the accelerator is to give scientists an advanced tool with which to investigate nature. Knowledge derived from such investigations is continually adding to man's understanding of nature and increasing the technological capacity of the United States.

Model "C" Stellarator

A new laboratory complex, the Model "C" Stellarator site of the Princeton Plasma Physics Laboratory, has been established at Prince-

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University, N.J. This laboratory is one of several atomic energy research centers working toward the production of useful power from energy released by controlled nuclear fusion reactions. Its experimental work centers around use of the stellarator for plasma confinement. The first-stage initial testing of the Model "C" Stellarator has been completed and the machine has been operating with plasma since August, 1961.

Transplutonium Element Production Program

The Commission's transplutonium element production program is directed toward the production of very heavy elements—americium 243, curium 244, californium 252, for instance—for research use in such things as radiation damage experiments and production of intense neutron beams. A second loading of kilogram quantities of plutonium is being irradiated in a Savannah River plant reactor to produce the transplutonium elements.[31] Products of the first loading should be ready for discharge, cooling, and subsequent processing by the end of next year. Techniques and procedures for the separation of the plutonium 242, americium 243, and curium 244 are currently being developed at the Oak Ridge National Laboratory.

After processing, the plutonium 242, americium 243, and curium 244 will be further irradiated in the High Flux Isotope Reactor (HFIR) now under construction at the Oak Ridge National Laboratory. The HFIR will have a power level of 100 thermal megawatts and a maximum thermal flux of about 5×10^{15} neutrons per square centimeter per second. Milligram amounts of californium and other important heavy elements are expected to be produced in the HFIR by 1965 and gram amounts several years later. The processing of the recycle americium, curium, and heavier elements and the handling of the large quantities of product californium and other radioactive heavy elements, requires a very highly shielded hot cell facility since some of them undergo spontaneous fission. Designs for such a facility are currently being evolved. Heavy element hot laboratories required for research utilizing the heavy nuclide products of this program are in existence or are planned for at several of the Commission's laboratories.

While planning and construction of this large scale program is underway, a smaller interim program is currently being carried out with irradiations in the Commission's Materials Testing Reactor (MTR) and Engineering Test Reactor (ETR) in Idaho to produce microgram quantities of californium and other heavy elements. The Commission's Lawrence Radiation Laboratory at Berkeley, Calif., has recently isolated 30 micrograms of californium from a long-term irradiation in the MTR. 5007406

[31] Those elements above plutonium (No. 94) on the periodic chart of elements.

For the preparation and investigation of the very heaviest nuclides, heavy ion accelerators and variable energy cyclotrons are important research tools. The Commission's Lawrence Radiation Laboratory at the University of California has a heavy ion linear accelerator (HILAC) in which the heaviest nuclides are used as targets for heavy ion bombardment. In this way, the heaviest transplutonium element—number 103—was discovered at Berkeley during the past year.

CLASSIFICATION AND DECLASSIFICATION

Curtailment of the Aircraft Nuclear Propulsion (ANP) activity during 1961 brought about an accelerated review of all the classified literature generated by the activity over the past years. More than 30,000 documents were examined in the light of the recently revised ANP Classification Guide and about half were declassified. Most of the other useful documents have been downgraded to Confidential. The information will be valuable for the development of high temperature, gas-cooled and molten salt reactors, which have important peaceful uses. Typical subject matter involved includes fused-salt reactor fuels, nichrome fuel elements, and studies of liquid metals as heat-transfer media, including their compatibility with various materials of construction.

The "Classification Policy Guide" adopted by the Commission in 1960 continues to exert a strong influence on all phases of the classification-declassification program. It has permitted the release of the technology of the isolation and handling of plutonium metal and its compounds, for example, thus giving impetus to the development of the program for the use of plutonium as a nuclear fuel for power and breeder reactors.

Continuing the policy of reviewing and updating classification guidance for the many and varied Commission activities, a number of program guides have been completely revised. The more important of these are the classification guides for Naval Nuclear Propulsion, Systems for Nuclear Auxiliary Power (SNAP), and the Nuclear Rocket (Rover).

A meeting in October between representatives of the Commission and the United Kingdom Atomic Energy Authority reviewed and recommended changes in the joint U.S.-U.K. atomic weapons classification guide. The changes are now being submitted to the Commission and the British Government, respectively, for final approval and adoption.

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The Commission's over-all information program has three basic purposes, consistent with national security: to fulfill the informational needs of the nation's news media; to provide the means for promoting better individual understanding of atomic energy; and to furnish technical materials that will be of aid to the scientific and technological community. Highlights of the latter two programs during 1961 include:

- The Commission's American Museum of Atomic Energy at Oak Ridge, Tenn., had its millionth visitor.
- Fifteen new motion pictures were added to the Commission's library of films available for showing to professional and popular audiences.
- A new multi-purpose type of exhibit, "Your Stake in the Atom," was added to the nuclear energy demonstration units touring the nation; the number of "This Atomic World" exhibits designed especially for secondary school demonstration use is being increased from six to eleven because of the heavy demand for this type of unit.
- The number of abstracts printed in the Commission's "Nuclear Science Abstracts" journal reached a new yearly high of 33,063.
- A total of 6,200 new unclassified technical reports were made available to the public, setting a new record for any single year.
- Six technical books were published and seven were completed or on press.
- Contracts were signed with four societies for the preparation of a series of monographs.
- Four new Commission depository libraries, one within the United States and three in foreign countries, were established.

EXHIBITS AND EDUCATIONAL SERVICES

Exhibits

The 23 traveling atomic energy exhibits operating within the Commission's Domestic Exhibits Program during 1961 were viewed by 1,333,936 in 48 States. During the six years since formal establishment of this exhibit program for laymen, the traveling units have been viewed by 38,057,698 persons in the 50 States.

In August, the Commission's American Museum of Atomic Energy welcomed its millionth visitor. The Museum began operation March 19, 1949, on the day that the general public was first given free access to the Oak Ridge community. Housed in a building that originally served wartime Oak Ridge as a cafeteria, the Museum has grown to

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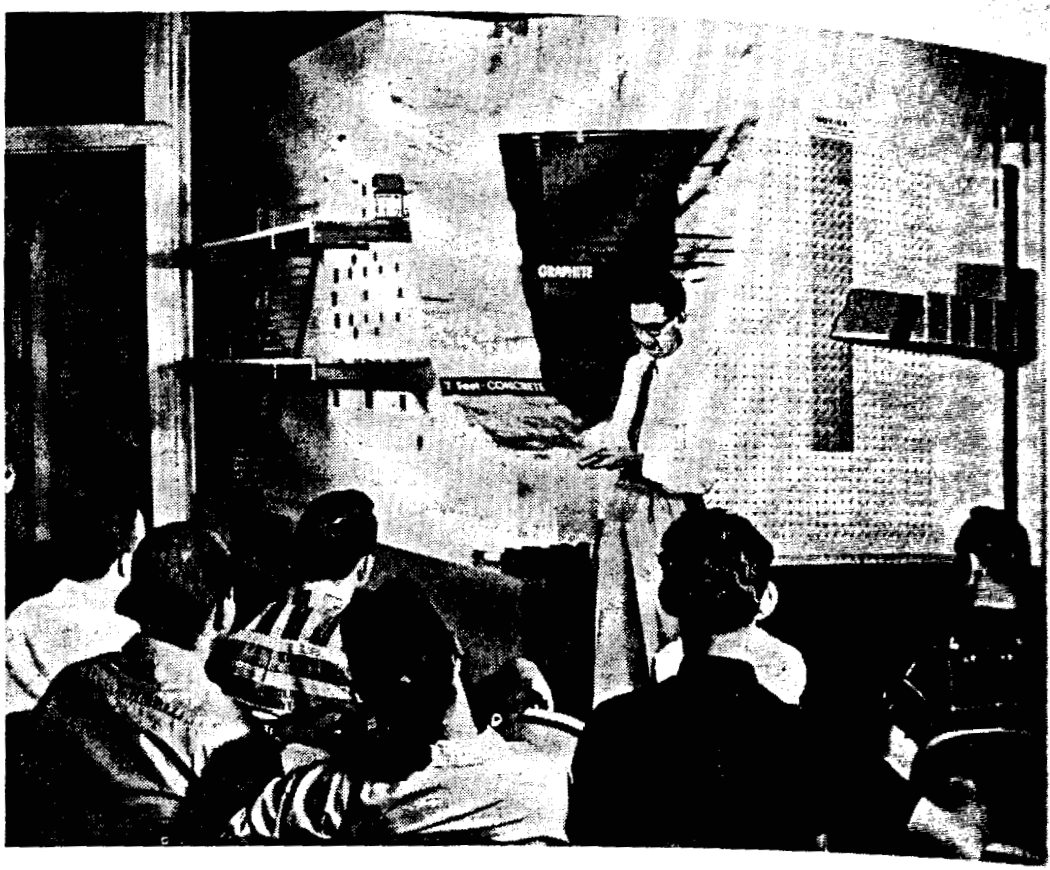

Museum Display. The Commission's American Museum of Atomic Energy at Oak Ridge, Tenn., recorded its millionth visitor during August 1961. The museum has been in operation since 1949. The museum features trained demonstrators using intricate working and scale models to explain the basic principles and applications of atomic energy to visitors from throughout the United States and many foreign countries. Photo shows a working demonstration of the Oak Ridge Graphite Pile Reactor.

approximately 12,000 square feet of exhibits and demonstrations on the basic principles, current applications, and possible future roles of atomic energy. The Museum building also houses the Museum Division of the Oak Ridge Institute of Nuclear Studies—contract operator of the Museum and the traveling exhibits for the Commission. The building also serves as a training center for the exhibits managers and provides the design and fabrication facilities needed for development of the various exhibit components.

Design of an entirely new "multiple purpose" exhibit, "Your Stake in the Atom", began in January and fabrication of the prototype unit was completed in time for late Summer and Fall trial showings in Maryland and North Carolina. The new exhibit is housed in an unusual "Exhibidome", a 50-foot-diameter aluminum geodesic framework which supports a plasticized nylon canopy. Visitors to the Exhibidome find the perimeter lined with instructive animated exhibits and periodically are shown an unusual three-screen, multiple-sequence

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motion picture and a short stage demonstration which increase their understanding of atomic energy. As "Your Stake in the Atom" tours State, the Exhibidome is sited in major communities for approximately a week. At the same time, trained demonstrators traveling with the exhibit present assembly programs on atomic energy to the students of neighboring high schools, before civic clubs, and other organizations. The exhibit also includes a special literature display which is set up in a nearby library to encourage reader interest in books and periodicals dealing with atomic energy. As in the case of the five mobile walk-through "Atoms at Work" exhibit vans which have been on tour for several years, "Your Stake in the Atom" will operate under schedules sponsored jointly by the National University Extension Association and the United States Junior Chamber of Commerce. The "Atoms at Work" units have been in use for six years.

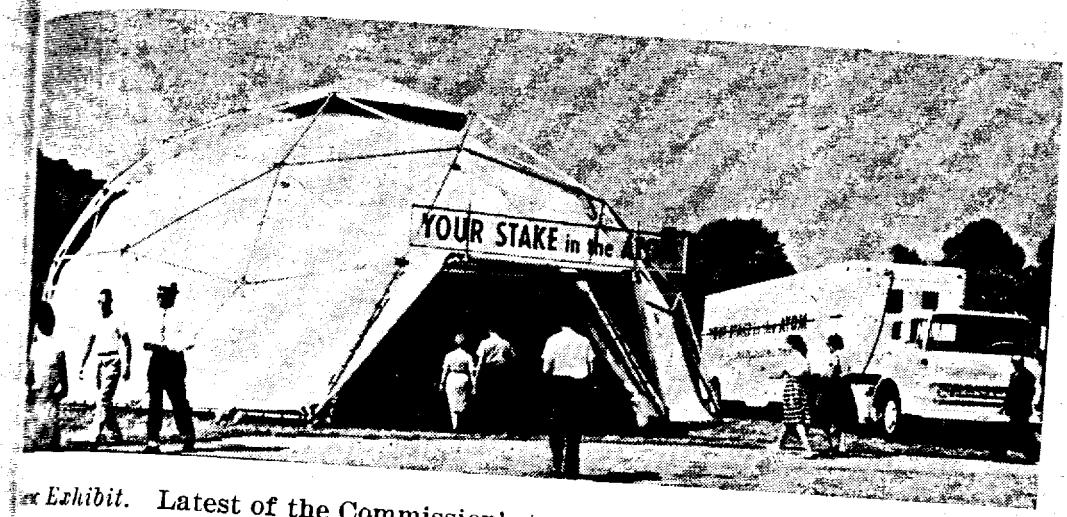

Exhibit. Latest of the Commission's traveling exhibits to be put into operation is the "Your Stake in the Atom" which serves a dual purpose. The outside of the unique "exhibidome" is shown *above*. In addition to static displays, the exhibit features short demonstrations of atomic energy principles and applications by trained instructors. In conjunction with a local showing of the exhibit, these instructors present longer "This Atomic World" programs at student assemblies in the local schools.

The Commission's two large manned "You and the Atom" exhibits were used during the Summer and Fall to satisfy needs of State Fairs and larger population centers. The ten unmanned package-type "Atoms in Action" exhibits were booked heavily throughout the year in schools, conventions, county fairs, and museums.

Among the most successful and continuingly popular of the Commission's traveling exhibits have been the six "This Atomic World" demonstration units, used to present the basic principles of atomic

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energy to secondary school assembly audiences and science classes. Since usually each of the six demonstrators can make such presentations in only one school per school day, the existing units have been able to serve only 1,000 schools during each nine-month school year. This falls far short of the demand created by the approximately 80,000 public and private secondary schools in the United States. Accordingly, another "This Atomic World" unit was added during the year, and demonstration equipment was constructed for four more units which will begin operation late in the 1961–62 school year. Also, to give students an appreciation of possible future uses of atomic energy in space exploration and other geophysical research programs, a new "Atomic Frontiers" section was added to the demonstration.

Most specialized of the Commission's traveling exhibits is the "Nuclear Information for Science and Industry" which is manned by Commission staff members. It is used to inform scientists and engineers about the scope of atomic energy technical information available to them, where it may be located, and how it may be obtained and used. This technical information exhibit was displayed at the national meeting of the Health Physics Society; the National Symposium on Aero-Space Nuclear Propulsion; the "Atom Fair" of the American Nuclear Society, and the Atomic Industrial Forum during 1961.

Educational Literature

The number of requests for all types of atomic energy information addressed to the Commission's Headquarters, to Commission Offices in the field, and to major contract operators of Commission facilities continued unabated during 1961. In response to these requests, approximately 85,000 packets of informational literature, reading references, and individual answers to specific questions were supplied to college, secondary school, and elementary school students, teachers, librarians, and guidance counselors; to adult study groups, teachers' institutes, conferences, and seminars; and to the general public.

FILMS

During the reporting period, the Commission's 10 domestic motion picture libraries, stocked with 175 popular and professional-level films, loaned them for more than 91,000 showings viewed by an estimated 3,265,000 persons. The film libraries and the geographical areas they supply are listed in Appendix 7.

Approximately 80 professional-level films were on loan from the Commission's liaison offices in London, Tokyo, Brussels, and Buenos

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Aires, with French and Spanish versions of about 45 films available through the latter two offices.

In June, the technical film, "Gas Cooled Reactor Experiment," which was produced through the Idaho Operations Office by the Air Force's Lookout Mountain Air Force Station, for the Commission and the U.S. Army Corps of Engineers, was given a finalist award by the Industry Film Producers Association on the basis of technical excellence.

The Commission added 15 films to its motion picture libraries during the reporting period. Motion pictures added were:

Professional

ANALYSIS OF NUCLEON-NUCLEON SCATTERING EXPERIMENTS, 50 minutes, color, produced by the University of California Lawrence Radiation Laboratory (Livermore); filmed-lecture by Prof. H. Pierre Noyes, giving an overall picture of the route followed in passing from single-, double-, and triple-scattering experiments to the scattering matrix in terms of phase shifts.

DISPERSION THEORY APPROACH TO NUCLEON-NUCLEON SCATTERING, 50 minutes, color, produced by the University of California Lawrence Radiation Laboratory (Livermore); filmed-lecture by Prof. H. Pierre Noyes, outlining some of the main ideas and techniques used in the calculation of the nucleon-nucleon scattering matrix from its analytic properties and unitarity.

INTRODUCTION TO HIGH VACUUM, 20 minutes, color, produced under the supervision of Brookhaven National Laboratory for the Atomic Energy Commission and the American Vacuum Society; a summary of high vacuum: what it is, the pump devices for attaining it; gauges for measuring high vacuum, uses of high vacuum.

Professional and Popular

NUCLEAR REACTORS FOR SPACE, 20 minutes, color, produced by Atomics International for the Commission; summary of the SNAP (systems for nuclear auxiliary power) program aspect devoted to heat-production from nuclear reactors, stressing safety aspects.

ATOMIC VENTURE, 25 minutes, color, produced by the General Electric Co.; summary of the Dresden Nuclear Power Station from concept, through construction, to testing and operation.

PLUTONIUM FUEL FABRICATION, EBR–I, MARK IV, 10 minutes, color, produced by Argonne National Laboratory. Film de-

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scribes the techniques and precautions observed in manufacture of EBR–I Mark IV fuel. Although the fuel is experimental in nature, the handling techniques and precautions are generally applicable to plutonium fabrication.

ATOMIC WEATHERMAN: ST–90 ISOTOPIC APPLICATIONS, 20 minutes, color, produced by Martin-Nuclear for the Commission; traces the development of strontium 90 titanate (ST) isotopic power sources. Although emphasis is accorded the automatic weather station installed in the Arctic, the breadth of other sea and land applications is indicated.

UNDERSTANDING THE ATOM, PART I: ALPHA, BETA AND GAMMA, 44 minutes, black and white, produced by the New York University Television Production Center for the Commission; filmed-lecture by Dr. Ralph Overman, Director, Special Training Division, ORINS, summarizing the modern concepts of the origin of alpha, beta and gamma radiation; describes how new nuclei are formed and subsequently break apart into the various components of the three most basic types of radiation.

METALS FRONTIER, 22 minutes, color, produced by the Iowa State University Film Production for the Iowa State University Institute for Atomic Research and the Commission's Ames Laboratory; highlights in the operations of Ames Laboratory during investigation of the "rare earths", by illustrating steps in the development of the process for production of yttrium metal.

Popular

THE INTERNATIONAL ATOM, 28 minutes, color, produced by the United Nations and the International Atomic Energy Agency; summarizes peaceful uses of atomic energy in power and propulsion, nature and uses of radioisotopes in agriculture, industry, medical diagnosis and treatment. Basic physical research and international cooperation in training are discussed. Produced with the cooperation of 12 countries.

ATOMS AT WORK: THE LATIN-AMERICAN EXHIBIT, 14 minutes, color, produced by the U.S. Department of Agriculture for the Commission; describes the Commission's exhibit on peaceful uses of atomic energy during its Latin American tour, including Rio de Janeiro and Buenos Aires.

THE ATOM IN THE HOSPITAL, 13½ minutes, color, produced by the Handel Film Corporation with the cooperation of the City of Hope Medical Center, the Medical Center of the University of California, and the Commission; the film is a visit to the City of Hope

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Medical Center to see its stationary cobalt source, its cesium ring rotational therapy unit and its total body irradiation chamber, and to the University of California at Los Angeles Medical Center to view its total body counter facility.

OPPORTUNITY UNLIMITED: FRIENDLY ATOMS IN INDUSTRY, 28 minutes, color, produced by the Army Pictorial Center for the Commission; a summary of the industrial applications of radioisotopes in nuclear gaging, radiography and tracing.

CONTROLLING ATOMIC ENERGY, 13½ minutes, black and white, produced by United World Films, Inc.; a basic teaching film describing radioactive atoms, measuring radioactivity, nuclear fission, controlled chain reaction, nuclear reactors, radioisotope uses in biology and medicine, agriculture, industry and research.

ATOMS ON THE FARM, 12 minutes, color, produced by the U.S. Department of Agriculture for the Commission; describes the Commission's exhibit on atomic energy in agriculture at the first World Agriculture Fair, New Delhi, winter of 1959–60.

TECHNICAL INFORMATION ACTIVITIES

Technical Publications

Nuclear Science Abstracts

The Commission's "Nuclear Science Abstracts", the only abstract journal in the world solely devoted to nuclear science and technology, has shown a steadily increasing growth from 4,000 abstracts in 1948 to more than 33,000 in 1961. In 1960, the figure was 26,000. This growth is attributable to the increase in unclassified research within the Commission, the steadily increasing domestic and foreign research and development in the nuclear field, and the increased interest in foreign language translation.

The use of machine processing techniques, begun in 1959, has made possible the inclusion of personal author, corporate author, subject, and report number indexes in each issue, as well as the rapid cumulation of these indexes. At the completion of Volume 15, a five-year cumulated index will be issued. Multivolume indexes were made available for Volumes 1–4 and 5–10. Cumulative indexes for Volume 11–15 are expected to be ready during the first quarter of 1962. "Nuclear Science Abstracts," through its informative abstracts, provides scientists and engineers in the national nuclear energy program and the international scientific community with an awareness of the current nuclear literature. Through extensive indexes it provides the means for retrospective retrieval of the nuclear literature generated during the past two decades.

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During 1961, the publishing cycle was shortened to the point where a maximum of only eight weeks elapse between the receipt of a document and the distribution of the issue of Nuclear Science Abstracts in which it is abstracted and indexed.

Mechanization of NSA. To cope with the increasing volume of literature on nuclear energy, studies are being conducted on how to utilize the information-handling ability of electronic computers. The indexing of NSA can be handled on a computer but certain compromises are necessary and these are now the subject of a detailed study.

Distribution of Reports

A total of 943 copies of classified reports was sold during 1961 to access permit holders under the Commission's Civilian Application Program, and 168,219 copies of unclassified reports were provided to the Department of Commerce, Office of Technical Services (OTS), for sale to the public. During the year, 6,200 new unclassified report titles were made available for sale through OTS, and were added to the collections of the Depository Libraries throughout the United States and abroad, bringing the depository collections to a new total of approximately 40,000 titles.

Bibliographies

The Commission published numerous formal bibliographies[32] during calendar 1961. Some of the subjects covered include: *Graphite*, *Controlled Thermonuclear Reactions*, *Radioisotopes in Agriculture*, *Nuclear Explosion Effects on Structures*, *Radioisotopes in Medicine*, *Criticality*, *Radiation Shielding*, *Plutonium*, *Radioisotopes in World Industry*, and *Radioactive Fallout*. These bibliographies are annotated and contain extensive subject and author indexes.

Technical Symposia Papers

During the reporting period, the Commission published 32 collections of papers presented at scientific and technical symposia, meet-

[32] "Bibliographies of Interest to the Atomic Energy Program" (TID 3043, Rev. 1) available from Office of Technical Services, U.S. Dept. of Commerce, $3.00. Supplements 1 and 2 to TID 3043 listing additional bibliographies are also available from OTS for $2.25 and $1.75 respectively. "Informal Listing of Bibliographies of Atomic Energy Literature," published irregularly updates TID 3043 and announces bibliographies in preparation. Available from Div. of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., without charge.

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and conferences. The Commission also issued a catalog[33] which and describes the proceedings of meetings of which the Commis- or its contractors were sponsors or co-sponsors, or in which they major participants.

Technical Books and Monographs[34]

Under the Commission's program of sponsoring the writing and publication of handbooks, monographs, and reference works in the of nuclear science and technology, six volumes were published during 1961:

Volume 2, *Fuel Reprocessing*, Reactor Handbook (2nd Ed.); Volume 3, *Physics and Shielding*, Reactor Handbook (2nd Ed.); The Rare Earths; Rare Earth Alloys; The Metal Plutonium; Nuclear Reactor Fuel Elements—Metallurgy and Fabrication; Applied Gamma-Ray Spectrometry; Principles of Cyclic Particle Accelerators; and Fast Reactor Cross Sections.

Seven volumes were completed or in press by the end of the year: Thermal Stress Techniques in the Nuclear Industry; Atomic Energy Deskbook; Radiation Effects on Organic Materials; Nuclear Propulsion for Merchant Ships; Effects of Nuclear Weapons (a revision); Volume 4, *Engineering*, Reactor Handbook (2nd Ed.); and Uranium Metallurgy.

Contracts were awarded for writing two books, entitled The Effects of Ionizing Radiation on the Nervous System, and Principles of Remote Handling.

The Commission's monograph program was formally initiated with the signing of contracts with four scientific societies for the preparation of a series of monographs. The American Institute of Biological Sciences is currently preparing six monographs (three titles remain to be selected): Cellular and Molecular Biology; Insect Physiology-Insecticides; and Mammalian Cells. The American Society for Metals is preparing six monographs: Fabrication of Nuclear Reactor Control Rods; Advanced Techniques in Powder Metallurgy; Materials for Control Rod Drive Mechanisms; Non-Destructive Testing of Nuclear Structural Materials Other Than Fuel Elements; Principles of Fabrication of Metallic Fuel Elements for Power Reactors; and Radiation Effects on the Toughness of Ferritic Steels. The American Industrial Hygiene Association is preparing three monographs: Beryllium;

[33] "Proceedings of Technical Meetings," available on request from the Division of Technical Information Extension, U.S. Atomic Energy Commission, P.O. Box 62, Oak Ridge, Tenn.

[34] "Technical Books and Monographs" sponsored by the U.S. Atomic Energy Commission. Available from the Division of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., without charge.

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Relationship of Particle Size to Lung Retention; and Technique of Particle Size Analysis. The American Nuclear Society is currently preparing three monographs: Control and Simulation of Nuclear Systems; Aspects of Reactor Heat Transfer; and Reactor Noise.

Technical Progress Reviews

Four quarterly Technical Progress Reviews [35] are published by the Commission. Each of the four reviews covers the developments in a particular area of the nuclear energy field and is aimed at both technical and management people. A subject index is provided for each of the reviews. The scope of each journal follows:

Nuclear Safety. This quarterly is intended for reactor designers, builders, and operators; regulatory, public health, and safety personnel; and others concerned with nuclear safety and related fields. Besides research and applications in this area, the journal reviews incidents, criteria, contamination, and monitoring. Highlights of activities of the Commission's Hazards Evaluation Branch, and Advisory Committee on Reactor Safeguards, are reported and recent safeguards reports are reviewed.

Power Reactor Technology. This review of reactor development is oriented toward the reactor engineer. It is intended to assist interested organizations in the task of keeping abreast of significant designs and applications in reactor technology for civilian application. In addition, available operating experience is reviewed and summarized.

Reactor Core Materials. This quarterly covers significant developments in the field of solid reactor core materials including fuel, fertile, moderator, cladding, and structural materials; nuclear poisons; and special fabrication techniques.

Reactor Fuel Processing. This review covers all aspects of the important fuel processing field—commercial, safety, metal preparation, waste disposal, and aqueous and non-aqueous processing.

Current Reporting on Projects

Considerable time often elapses between the start of a research project and its being reported in the literature. To enable scientists and

[35] Available by subscription (domestic, $2.00 a year; foreign, $2.50 a year), or by individual issue ($0.55), through Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

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ministrators to become aware of projects as soon as they are started. Commission has initiated a pilot run of a publication listing research and development projects in the fuels technology area. The project leader writes a short description of his project as soon as it is started. This information is then printed on punched cards which are sorted and automatically photographed. Indexes by subject, author and company are also produced using the same mechanical techniques. The quarterly issuance of this publication would cover Commission research and development projects.

Publication Exchanges

The Commission continued its program of obtaining information from domestic and foreign organizations through exchange agreements. In return for this information, the Commisssion supplies *Nuclear Science Abstracts* (*NSA*) and selected unclassified reports. During 1961, 33 new exchanges were initiated, bringing the total to 35 foreign exchanges in 44 countries, and 103 exchanges with domestic organizations. A number of exchanges were terminated by mutual agreement.

Publications received on exchange are abstracted in NSA. Copies of reports are distributed to domestic depository libraries and journals made publicly available through the interlibrary loan services of the Library, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.

Translations

Approximately 600 Commission-sponsored translations were announced in "Nuclear Science Abstracts," distributed to official requesters, and made publicly available through the Office of Technical Services and the Special Libraries Association Translation Center, John Crerar Library. Among the translated monographs were the following titles: "Contribution to the Study of Medullary Syndrome Following Irradiation: An Experimental Study;" "Theory of Notch Stresses: Principles for Exact Calculation of Strength with Reference to Structural Form and Materials;" "Oscillation Matrices and Kernels and Small Vibrations of Mechanical Systems;" "The Magnetic Properties and Structure of Matter;" and "Hydrodynamics and Heat Transfer During Boiling in High Pressure Boilers."

There was continued participation in the program administered by the National Science Foundation whereby foreign currencies accruing to the United States from the sale of Surplus Agricultural commodities are used for translation purposes (Public Law 480, Section

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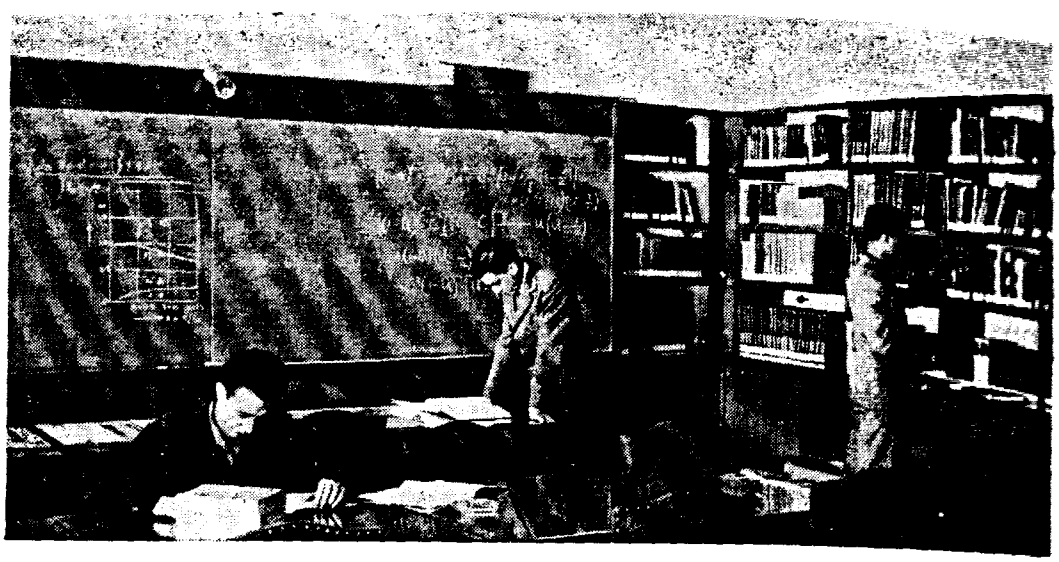
K). Under this program, Volume 2 of the Soviet journal, "Radiochemistry," and Volume 1 of the Soviet "Journal of Inorganic Chemistry" were translated in Israel. Other translations under this program were prepared in Poland and Yugoslavia.

An indexed title-listing of all Commission-held tranlations was published in 1961.[36] More than 7,000 translations are listed and indexed by source and author.

The Commission's translations are also announced in the OTS publication "Technical Translations" issued by the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., and in the European Atomic Energy Community (Euratom) translation announcement journal, "Transatom Bulletin."



Mexico City Library. As a part of its program of encouraging the growth of nuclear industry and science, the Commission has established 183 depository libraries, each of which contain approximately 40,000 technical reports and books dealing with atomic energy. Eighty-seven of these depository libraries are in foreign countries. Photo shows a corner of the library in Mexico City which houses a Commission depository library.

Depository Libraries

During 1961, four more Commission depository libraries—one domestic and three foreign—were established. In the United States, a new library was located at the University of North Dakota. Abroad, one library was established in Brazil at the Institute of Atomic Energy, São Paulo, and two were established in Indonesia, one at Gadjah

[36] "Translation Title List and Cross Reference Guide," edited by Frances E. Stratton (TID–4025). Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for $5.25.

"Translation List," published irregularly, updates TID 4025 and announces translations in process. Available from the Division of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., without charge.

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ifada University and the other at the Institute of Technology, Bandung. There are now 86 AEC depository libraries in the United States and 87 outside the United States assigned to 61 countries and international organizations concerned with atomic energy.

The Commission is cooperating in a program sponsored by the National Science Foundation for establishing 12 regional depository libraries that will house and service collections of all U.S. Government reports. The program is being administered by the Office of Technical Services, Department of Commerce. Eleven of the libraries chosen were already AEC depositories; the exception being the University of Denver.

To assist the Latin American countries in making more complete use of their depository collections, the Commission conducted two information workshops in cooperation with the National Science Foundation and the Inter-American Nuclear Energy Commission. The first workshop was held in Rio de Janeiro, Brazil, during April and was attended by information specialists from Brazil, Argentina, Mexico, Panama, and Paraguay. The second workshop was held in Lima, Peru, during October with participants from Peru, Chile, Colombia, Ecuador, and Venezuela.

EDUCATION AND TRAINING

Early in 1961, the Commission reorganized its educational assistance activities which provides aid to non-profit educational institutions in establishing or expanding nuclear curricula. A Coordinator of Nuclear Education and Training was established in the Office of the Assistant General Manager for Research and Development. The Coordinator acts as a focal point within the Commission for nuclear education and training, and is responsible for overall coordination of educational activities including the development of policy, plans, programs, procedures, and reporting associated with these activities. (A summary of the Commission's program of training for foreign nationals is carried under the International Activities section of this report.)

The Commission's educational assistance activities are designed to assist educational institutions in accomplishing the following three major objectives: (*1*) to assure a continuing supply of capable nuclear scientists and engineers for the atomic community; (*2*) to diffuse nuclear technology throughout all pertinent curricula; and (*3*) to assist in orienting the public on nuclear energy.

The bulk of the Commission's educational assistance activities through 1960 were directed mainly to the fulfillment of the first ob-

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jective. However, greater emphasis is now being placed on the second objective of diffusing nuclear technology throughout the educational system above the elementary grades, i.e., the study of the applications of the principles and phenomena of nuclear science in physics, chemistry, biology, and other disciplines and in engineering and industrial techniques and processes. This covers the academic range from the high school level to postgraduate activities.

Accomplishments in 1961 through Commission-sponsored programs are summarized as follows:

	Number trained	
	1961	Since 1946
Faculty Trained in life and physical sciences and engineering, including radioisotopes and radiation:		
College faculty	413	1,242
High school faculty	400	1,527
Total	813	2,769

	No. of institutions receiving grants		Granted	
	1961	To date	1961	Since 1956
			(in millions)	
Equipment Grants in life and physical sciences and engineering including isotope technology	248	471	$3.5	$21.3

	No. of fellowships		Cost
	1961	To date	1961
			(in millions)
Fellowships—life and physical sciences and engineering	222	1,135	$1.4

Loan of Materials

For educational purposes, nuclear materials such as normal and enriched uranium, graphite, heavy water, and neutron sources are loaned to universities. During 1961, material valued at approximately $1.4 million was loaned; at year end, the total value since 1956 to date was approximately $12.4 million.

Physical Sciences and Engineering

Faculty Training

The past year represented the sixth consecutive year that summer institutes have been conducted under the joint sponsorship of the Commission and the American Society for Engineering Education (ASEE) to provide opportunities for advanced training in nuclear science and engineering, as 128 faculty members attended seven institutes held at Purdue University, Pennsylvania State University, North Carolina State College (two institutes), Stanford University, Argonne National Laboratory, and University of Michigan. Since

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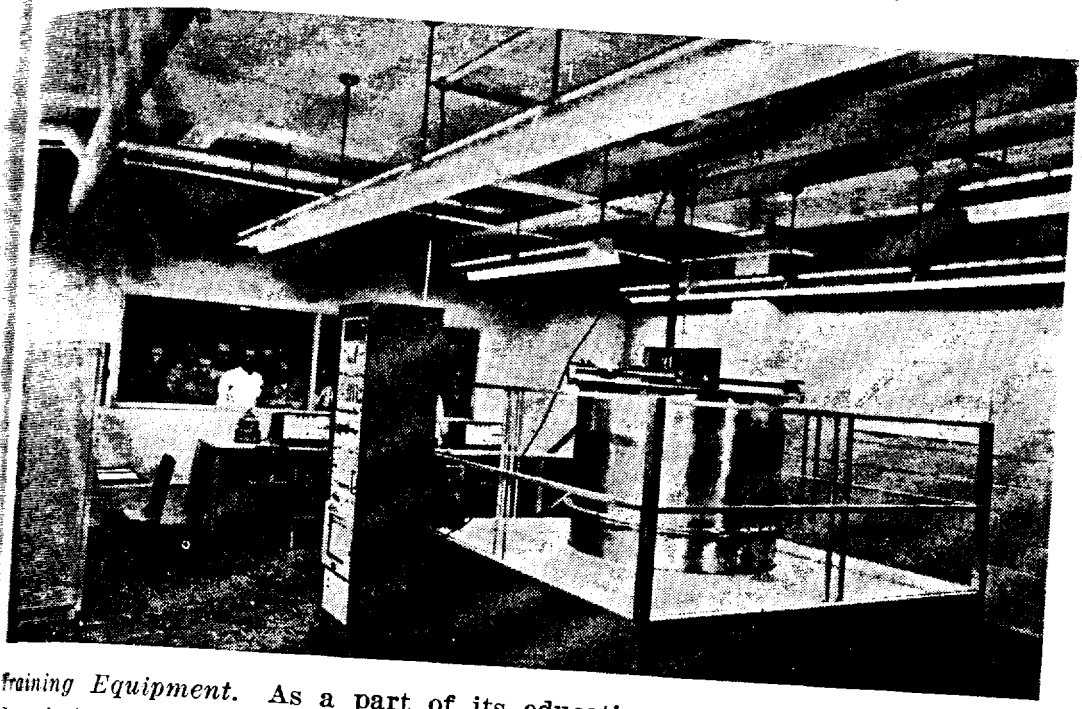
inception of the faculty training program, a total of 709 faculty enrollments from 166 institutions have been trained in 35 AEC–ASEE summer institutes.

In 1961, the Oak Ridge Institute of Nuclear Studies conducted an eight-week summer institute in nuclear physics for small college science faculty. Twenty-one faculty members participated in this institute. Plans are underway for three such institutes in 1962. The Commission emphasis on faculty training is being shifted from engineering to the nuclear aspects of chemistry and physics for faculty members of Colleges of Arts and Sciences. These institutes will be sponsored jointly with the National Science Foundation.



Training Equipment. As a part of its education and training program, the Commission provides funds for educational institutions to acquire nuclear equipment for teaching purposes. Photo shows students of Northeastern University, Boston, Mass., looking at the sub-critical assembly and associated equipment obtained by the university through a Commission grant. The sub-critical assembly is a small chain reaction. Such plutonium-beryllium neutron sources are provided schools on a loan basis by the Commission.

Equipment Grants

Educational institutions at the college level are provided funds to acquire nuclear equipment for teaching purposes. Support is granted for both undergraduate and graduate laboratories. Undergraduate support is granted primarily to those institutions which demonstrate that significant numbers of their science and engineering majors go on to graduate study. In fiscal year 1961, the Commission

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made grants totaling $3.5 million to 248 universities and colleges for specialized nuclear laboratory equipment such as subcritical assemblies, scalers, counters, pulse height analyzers, and neutron howitzers. This brought the total Commission grants in the physical sciences and engineering to $16.6 million since 1956.

The Commission's nuclear science and engineering fellowship program began in 1957–58 with 96 first-year appointments. Since that time, including the 1961–62 appointments (159), 490 fellows have received 690 one-year appointments for study at the first-, intermediate-, or terminal-year level. Fifty-six colleges and universities in the United States offering courses in nuclear education participate in this fellowship program.

Nuclear Materials Services

The nuclear materials services program is made up of two parts: (*1*) to assist educational institutions to acquire nuclear materials needed for their training programs, and (*2*) to provide fuel-cycle assistance for university reactors under the research reactor assistance program.

During 1961, the Commission approved loans to 103 schools without charge for neutron sources, graphite, heavy water, natural uranium reject slugs, and enriched uranium for instructional purposes. Since this part of the program was initiated in 1956, nuclear materials valued at $12.4 million have been loaned to 221 institutions.

Under the research reactor assistance program, in 1961, the Commission agreed to: provide additional funds for fuel fabrication for the Georgia Institute of Technology reactor, provide funds for fuel fabrication and loan fuel materials for the Cornell University zero power reactor, provide additional funds for fuel fabrication and loan additional fuel materials for the Massachusetts Institute of Technology reactor, and loan fuel materials for the Quehanna reactor, acquired by the Pennsylvania State University as a gift from the Curtiss-Wright Corp. The fuel fabrication grants totaled $318,000 and the value of the materials loaned was $439,000. Since inception of this program in 1954, reactor projects have been assisted in this manner at ten educational institutions, the total value of materials loaned being $1.7 million and total funds authorized for fuel fabrication being $622,000. The program is carried out in cooperation with the National Science Foundation which provides grants toward the construction of university research reactor facilities.

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Temporary Appointments at National Laboratories

During 1961 a temporary appointments program was conducted for faculty, graduate, and undergraduate students at the Argonne National Laboratory for periods of from three months to one year. At the Oak Ridge National Laboratory, faculty members participated during the summer of 1961. Temporary appointments are also available on a more limited basis at other Commission laboratories.

Use of Facilities

During the 1960–61 academic year, 18 universities were sponsored by the Associated Midwest Universities in a program of laboratory experiments at Argonne National Laboratory and 163 students used Argonne's facilities for a total of 516 student days of instruction. The majority were enrolled in graduate study at their respective universities. Eighty-three days of staff and facility time were given to this portion of Argonne's cooperative effort with the universities. One-half of the students' time was spent on the Argonaut and AGN–201 training reactors. The remainder of the instruction was distributed among other facilities for experiments in fuel fabrication, fuel reprocessing, heat transfer, reactor control, nondestructive testing, and analog computation.

Life Sciences

Faculty Training

During the summer of 1961, faculty training in radiation biology was offered by the Commission through 24 six- to eight-week courses—16 for high school teachers, six for college teachers, and two for high school and college faculties combined. These courses were held at 23 universities.[37] In the fall of 1961, three in-service sessions of one or two classes per week were started at three universities (Montana State University, Texas Women's University, University of Washington) providing the same type of radiation biology training for a

[37] University of Michigan, Oak Ridge Institute of Nuclear Sciences, University of Rochester, Syracuse University, Tulane University, and University of Washington (college teachers); Adelphi College, Bowdoin College, University of California, Florida State University, Howard University, University of Kansas, University of Minnesota, Montana State University, University of New Mexico, Ohio State University, University of Puerto Rico, Purdue University, Texas Women's University, University of Washington, Wayne State University, and University of Wyoming (high school teachers); University of Hawaii and Tuskegee Institute (high school and college teachers).

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total of 55 high school teachers. At the same time, a full academic-year course for 10 college teachers was initiated at Cornell University.

To date, 1,127 high school teachers and 153 college teachers have received training in 64 institute sessions conducted over the past five years under Commission sponsorship. At the end of the 1961–62 program, the total number trained will be 1,527 high school and 293 college instructors; a total of 1,820 teachers in 92 institute sessions since the faculty training program was started in 1956.

Equipment Grants

During 1961, 140 non-profit educational institutions requested grants of funds for equipment to be used in radiation life sciences courses. The Commission awarded 114 grants for $910,620 to 107 educational institutions.

Since the beginning of the life sciences equipment grants program in 1957, a total of 466 grants totaling $4,657,947 have been awarded to 292 schools.

Fellowships

Industrial Fields

Eight physicians were awarded fellowships for graduate training in *industrial medicine* for the academic year 1961–62. Two additional fellows were awarded a second year of training. The fellows are at the medical schools of Pittsburgh, Yale, Rochester, and Harvard Universities.

Sixty-eight fellowships have been awarded in this program, which has been administered for the Commission by the University of Rochester since 1950.

Six *industrial hygiene* fellowships were awarded for the academic year 1961–62 bringing the total number of awards to 62. Wayne State University was added to the list of participating universities which includes the University of Cincinnati, Harvard University, the University of Pittsburgh, and the University of Michigan.

There are 44 *health physics* fellows for the current academic year 1961–62. Twenty-seven of last year's fellows are continuing graduate study. Approximately 600 fellows have received this specialized graduate training since 1950 at the universities and Commission installations now cooperating in the program: Vanderbilt, Puerto Rico, Rochester, Harvard, Michigan, Kansas, Washington (Seattle), California (Berkeley) universities, together with Oak Ridge, Brook-

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ven, and Argonne National Laboratories, General Electric Co. Hanford, Wash.), National Reactor Testing Station (Idaho), and O. Lawrence Radiation Laboratory, University of California Berkeley and Livermore, Calif.).

The program for *advanced training in health physics*, to equip experienced health physicists for senior positions, began in the academic year 1959–60, with five graduate fellows. One man has obtained his doctorate from the University of Michigan and fellowship renewals were granted to the other four. Five fellows began training in the academic year 1960–61, and five in 1961–62. These fellowship programs are administered for the Commission by the Oak Ridge Institute of Nuclear Studies.

Radiobiology Lecture Program

Through this program, conducted under the auspices of the American Institute of Biological Sciences, 30 biologists actively engaged in research work at universities and Commission installations in various areas of radiation biology, visited 36 small colleges and universities. They offered formal lectures to students and faculty, advised faculty members on their teaching and/or research programs, and spent some of their time in conferences with students.

Effect of Programs

Reports from schools receiving grants show that approximately 150 courses have been expanded to include instruction in aspects of nuclear technology related to medicine, public health, agriculture, pharmacy, veterinary medicine, and general biology. Thirty-three of 74 institutions enlarged laboratories and/or general teaching facilities for use of grant equipment, and approximately 25 new faculty members have been added or assigned in the subsequent programs. Enrollment in courses relating to radiation biology during the academic year 1960–61 increased by 600, or approximately 29 percent.

Radioisotope and Radiation Education

Faculty Training

As part of its faculty training program, and in cooperation with the National Science Foundation, the Commission during 1961 supported five college faculty summer institutes on the use of radioisotopes, radiation principles, and safe handling techniques. The insti-

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tutes, held at the Oak Ridge Institute of Nuclear Studies, University of California at Berkeley, University of Oklahoma, University of Michigan, and Louisiana State University, received applications from 750 instructors for the 124 openings available. The participants represented faculties from approximately 115 colleges and universities.

Equipment Grants

Under its radioisotope equipment grant program related to the physical sciences and engineering, the Commission made grants totaling $878,523 to 76 institutions in 35 states during the past year. Funds went for acquisition of radiation detection devices, radioisotope handling equipment, and related laboratory demonstration apparatus. The grant program is coordinated with a similar educational assistance program for the life sciences.

Training Assistance

The Commission also assists in training physical scientists and engineers in radioisotope technology. During 1961, 317 students attended two to six week courses in radioisotope research and applied technology at Oak Ridge Institute of Nuclear Studies.

A laboratory manual with accompanying instructor's notes for radioisotope experiments in the college chemistry curriculum has been compiled. Copies have been distributed to over 700 colleges and universities to encourage and assist radioisotope training. The manual and notes have also been placed on public sale.[38]

Mock-ups of equipment in radiochemistry and industrial radioisotope devices have been designed for training purposes. Full-scale engineering drawings permitting construction of these training aids have been prepared for general distribution.[39] These devices have certain advantages over their industrial and commercial counter-parts since they are specifically for laboratory demonstration and training.

Educational Films

A film, "Industrial Applications of Radioisotopes," prepared by the Army Pictorial Service for the Commission was exhibited widely

[38] Radioisotope Experiments for the Chemistry Curriculum—Student Workbook. TID-6374; Radioisotope Experiments for the Chemistry Curriculum—Instructor Notes. TID-6375. Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., $2.00 and $1.00, respectively.

[39] CAPE 811–822; available from Cooper-Trent Blueprint and Microfilm Corp., 2700 Wilson Blvd., Arlington 1, Va., the Commission's distribution contractor for engineering materials.

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during the year. Directed to industrial management, engineers, and technicians, the film was photographed in 26 industrial plants and laboratories which use radioisotopes to help produce rubber products, sheet metal, plastics, paper, nylon, ships, petroleum, foods and other products. Examples of thickness, density, and level gaging, radiography and tracer applications are shown.

As a contribution to world development, the Commission has translated this film into five languages: French, Spanish, Portuguese, German, and Japanese.

A popular-level film, "Opportunity Unlimited—Friendly Atoms in Industry," narrated by Commentator John Daly, also has been produced for the Commission. Directed to the general public and suitable for TV showing, the 28-minute color film is taken in part from the more technical film described above. It illustrates how radioisotopes contribute to more efficient industrial production and quality control of numerous consumer products.

The new field of educational television has been entered by the Commission's release of its first video-taped film. This 44-minute film presents some of the fundamental concepts of alpha, beta, and gamma radiation. It initiates a series of video-taped films to be released under the series title, "Understanding the Atom".

The above films may be borrowed for nonprofit group showing from Commission film libraries (see Appendix 7).

Other Activities

Because of the rapid world-wide developments in radioisotopes and radiation technology having potential benefits to U.S. and world industry if more widely recognized, the Commission has undertaken a program of monitoring and evaluating developments in the foreign-language literature. Information generated by this program is distributed through the usual educational and technical information channels.

In further efforts to familiarize U.S. industry and the educational community with the value of radioisotopes, the Commission has cooperated with various educational and industrial organizations in presenting a series of regional conferences covering radioisotopes techniques, specific applications, safety practices and regulatory controls. During 1961, six conferences were attended by 1,200 scientists, engineers and executives.

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Firefighter Instruction. Since fighting fires that may involve radioactive materials can be hazardous, especially to untrained personnel, the Commission conducts short, intensive instructor training courses for fire departments throughout the nation. In turn, these instructors hold training sessions for the men of their departments. In addition to methods of fire fighting to be used, the courses include the fundamentals of nuclear energy. Photo shows a group of California fire training instructors at the Commission course held in Stockton, Calif., during October 1961.

Industrial and Vocational Training

Assistance to Vocational Schools

During 1961, the Commission and the U.S. Department of Health, Education and Welfare (HEW) published material[40] for use in training firemen in regard to the hazards that may be encountered while fighting fires involving radioactive materials and how to avoid such hazards.

The publications were prepared on the basis of recommendations made by a committee composed of State directors of vocational education, firefighter trainers, the National Professional Curriculum Materials Committee for Trade and Industrial Education, the Commission, and the Office of Education of HEW. This material has been distributed to directors of vocational education in all 50 states and the District of Columbia. In addition, an intensive short-

[40] "Peacetime Radiation Hazards in the Fire Service", OE–84014—Orientation Unit, Instructor's Guide ($0.35); OE–84015—Orientation Unit, Student Manual ($0.30); OE–84019—Basic Course, Resource Manual ($1.00); OE–84020—Basic Course, Instructor's Guide ($0.50); OE–84021—Basic Course, Student Guide ($0.30); and OE–84022—Basic Course, set of 22 charts ($2.00); available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., at indicated prices.

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term instructor training course has been offered by the Commission to instructors within State vocational school systems who will teach the courses to firemen. During 1961, approximately 160 fire-fighter trainers attended the instructor training courses in Charlotte, N.C.; Stockton and Pasadena, Calif.; Salem, Oreg.; Albany, N.Y.; Richmond, Va.; and Ann Arbor, Mich.

A survey made late in the year by the Commission indicated that 44 States have already agreed to conduct fire-fighter training classes using the publications as textbooks.

There has been a continuing demand for the specialized course material[41] developed by the Stanford Research Institute for the Commission by both industrial organizations and State school systems. Instructors, using this material, are conducting classes in such States as California, Pennsylvania, Ohio, New Jersey, and Texas.

Reactor Supervisory Training

Shippingport Course

During the first part of 1961, 14 students completed a four-month nuclear training program course at the Shippingport Atomic Power Station. Eleven of the students were from the United Kingdom, two from Japan, and one from Sweden. No other course was scheduled for the year in view of the shutdown of the reactor for re-fueling. The next course is scheduled for January 8, 1962.

The training course is designed to give domestic and foreign supervisory personnel, engineers, and specialists a practical background in the particular fields of science and engineering which are not normally associated with conventional power stations, but which are essential to safe and efficient operation of a nuclear power station of the Shippingport type. It also provides an opportunity for actual experiences in operation, maintenance, health physics, chemistry and testing for this type of station.

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[41] SRIA–4, Development of Training Programs for Operating and Maintenance Personnel in Nuclear Power Generation Systems ($0.45); SRIA–11, Preparation for Nuclear Energy Training in a Trade Union ($0.50); SRIA–11a, Instructor's Guide Survey of Nuclear Energy and Power Plant Applications ($0.50); SRIA–12, Trial Presentations of a Nuclear Energy Training Course in Two Adult Vocational Education Programs ($0.55); SRIA–19, Instructor's Guide: Survey of Nuclear Fundamentals of Radioisotope Applications in Industry ($0.75); SRIA–20, Development of a Training Program for Radioisotope Workers in Industry ($0.75); SRIA–21, Instructor's Guide: Radiation Safety ($0.75); SRIA–22, Development of a Radiation Safety Training Program for Industrial and Public Service Personnel ($1.00); and SRIA–23, Radiation Safety Training in a Naval Shipyard ($0.35), available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., at indicated prices.

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TRAINING OF STATE PERSONNEL

When, in 1959, Section 274 was added to the Atomic Energy Act of 1954 creating the AEC Federal-State program,[42] provision was also made for the Commission to make training available for State and local government personnel who may be involved in a State's radiation control program. The purpose of the training program is to assure that technically competent personnel will be engaged in the State program after the State has signed an agreement with the Commission to assume certain responsibilities in the control of byproduct materials.

Types of Courses

The academic training courses have been tailored to furnish instruction suitable to the criteria established for personnel in any radiation control program. The courses, which have been conducted since mid-1960, are of two types, one running a full year, the other being conducted over a ten-week period.

The one-year program. This program consists of nine months of academic study plus three months of field training. The academic study is at the graduate level and is presented at universities, such as Harvard or Michigan. The three months of field training is given as practical work in a Commission facility.

This course comprehensively presents the theory of radiation physics and the controls needed for health protection purposes. It is designed for personnel who will have positions requiring a high level of technical responsibility in the radiation control program.

The ten-week program. This course consists of ten 40-hour weeks of intensive training in health physics. Approximately half of the course is devoted to academic study and half to field training. The course is usually presented in Commission operations offices although it can be presented in universities that have a large radiation program. Primarily, this course is designed for personnel who will perform field work in a State radiation control program under supervision. Three such courses have been offered in the past year.

Orientation training. In addition to the academic courses, orientation training is available. This training consists of arranging for State personnel to visit AEC Headquarters in Germantown, Md., to study licensing and inspection procedures. The length of the orienta-

[42] See pp. 266–267, Annual Report to Congress (January–December 1959).

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tion program is flexible and is suited to the States' desires. State personnel also accompany Commission compliance personnel on inspections and investigations for orientation purposes.

Extension course. Since there has been a reluctance by the States to have personnel away from their normal duties for long periods of time, the Commission is considering the feasibility of conducting college extension courses on a local or regional basis, making training available to State agency personnel through late afternoon, evening, or Saturday classes. Training through this mechanism will, of necessity, require a longer period of time. In addition, since not all colleges have complete radiation laboratories, possible locations for such courses may be limited. With such a course, field training will have to be arranged for shorter periods, probably in the summers. A pilot extension course is now being planned.

Costs to States

One reason given by the States for not enrolling the anticipated number of personnel has been lack of funds for travel and living expenses for the students. This has been a prevalent statement on the part of cities and counties. The Commission pays the tuition and administrative costs of these courses to the institution presenting the course but does not pay stipends or cost of travel. The latter must be borne by the States or local government.

The Commission has worked closely with the U.S. Public Health Service in developing a possible 10-week extension course for State personnel.

CONTRACTING POLICY

Major activities in the Commission's area of contracting policy and practices during 1961 were:

- Revised Commission policies regarding improved contractor selection procedures were put into effect for those types of contracts where appropriate.
- New provisions were written into contracts covering operation of reactors which better delineate the duties of the contractor regarding safe operation of the reactor.
- Policies regarding reimbursement of contractors for costs involved in the preparation of bids and proposals, and incentive compensation, were revised.
- "Small business" contractors received 41 percent of the total dollar value of subcontract awards in Commission activities as compared with the 39.3 percent average for the period 1951–1961.

Contractor Selection Procedures

Revised Commission policies covering the selection of contractors for negotiated-type actions, where the technical and managerial requirements represent the primary consideration for award, were extended during the year to apply to all types of contractors, where appropriate. Similar policies were utilized previously only for architect-engineers and cost-plus-fixed-fee (CPFF) construction contractors.

These policies are designed to improve and tighten selection procedures, provide better criteria for selection of the best contractor for a given job, expedite the selection of contractors, insure greater contracting procedure consistency among the Commission's various Headquarters divisions and field Operations Offices, and help promote better understanding between the Commission and its prospective contractors.

Some of the more significant features of the policies and procedures are:

a. Requirement for inclusion of financial and legal representatives, in addition to the other qualified members, on boards for all selections requiring Headquarters approval [43] and for significant selections [44] in the field. Board membership may include representatives from other Operations Offices and/or Headquarters, where appropriate. The legal representative will participate as advisor to the board, but will not necessarily be a board member.

b. Requirement that requests for proposals contain an appropriate summary statement on the selection criteria to insure that the proposals will be as responsive as possible to the criteria to be used in the evaluation.

c. Assistance is to be obtained (whenever substantial work of a developmental nature will be involved in the contract) from a Commission national laboratory or other Commission research facility in the development of any technical specifications used in the request for proposals and in evaluating the feasibility of the technical features of the proposals.

Through appropriate incorporation in CPFF prime contractor procurement procedures, these policies will also cover subcontractor selections.

[43] Contracts requiring Headquarters' approval include those which cover the operation of Government-owned facilities, are above the managers' of field offices contracting authority or involve new or unusual contractual arrangements or undertaking likely to provoke unusual interest.

[44] The term "significant selections" means those which the manager of the field office considers to be of greater importance than his contractual authority, although the resultant contract may be within his delegated contractual authority.

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Expanded Health and Safety Contract Provisions

As a result of review and study following the SL–1 reactor incident,[45] additional contract provisions have been adapted for inclusion in new contracts and existing contracts when such contracts involve the start-up and/or operation of Commission-owned, non-licensed reactors, including critical facilities.

The additional provisions place emphasis on the contractor's nuclear safety responsibility for:

a. Preparation of detailed plans and procedures designed to assure the safe operation and maintenance of the reactor and obtaining Commission approval of these plans and procedures.
b. The carrying out of a training program assuring that the Commission-approved plans and procedures for nuclear safety are completely understood by all contractor personnel who are, or will be, engaged in the operation and maintenance of the nuclear reactor.
c. Assurance that all operational and maintenance activities are performed by qualified and adequately-trained personnel and, except as otherwise agreed in writing, are conducted at all times under the supervision of personnel who are able to quickly appraise and control emergency conditions that may give rise to the risk of a nuclear incident.
d. Establishment of a system of inspection (including review of inspection reports by highly competent technical groups) that will (1) provide frequent and periodic checks of reactor performance and of the qualifications and training of operating and maintenance personnel, and (2) provide for investigation of any unusual or predicted reactor conditions that might affect the safe operation of the reactor.
e. Reporting promptly to the Commission's contracting officer any change in the physical condition of the reactor or its operating characteristics that might affect its safe operation.

Cost Principles

The Commission's policies governing the reimbursement of its contractors to allow costs of preparing bids and proposals and incentive compensation were revised and issued[46] effective August 16, 1961. The new principles provide that:

a. The costs of preparing bids or proposals, whether successful or unsuccessful, which are properly chargeable to the division, plant, or other unit at which contract work is being performed, will be

[45] See pp. 35–39 and 141–145 of this report.
[46] Notice of the changes were published in the *Federal Register* on August 16, 1961.

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allowable if the subject matter is applicable to the Commission program. Such charges must not exceed one percent of direct material and labor costs for the contract work.

b. Incentive compensation will be allowable, provided the total compensation paid to any one individual is reasonable for the service rendered, does not exceed costs allowed by the Internal Revenue Service for tax purposes, and is pursuant to an agreement between the contractor and employee prior to the rendering of the services or an established plan consistently followed by the contractor, etc.

c. Compensation for personal services must be commensurate with that paid under the contractor's established policy and must conform generally with compensation paid by other firms of the same size in the same industry or in same geographic area for similar services. The Commission contracting officer will make a pre-contract determination that the prior practice of the company has produced reasonable total compensation to individual employees.

d. Bonuses and incentive compensation paid to employees other than those whose pay is directly reimbursed will not be allowed in construction and operating contracts where home office and general administrative expense is not allowable.

Small Business

Small business received a significant share of the total Commission subcontract awards during fiscal year 1961, totaling $277.4 million, or 41.4 percent of the $669.2 million total subcontract awards. By comparison, the small business share for the period, 1951 through 1961 was 39.3 percent. Small business received approximately $190.4 million worth of new prime contracts of the estimated $2.6 billion worth awarded during 1961.

The Commission and its cost-type contractors continued to participate in Small Business Administration-industry conferences held throughout the country, providing representatives and contractor's exhibits on subcontracting opportunities. Maximum practicable small business participation under the Commission's prime contracts and subcontracts continued to receive emphasis at the Commission's Operations Offices and by each cost-type contractor purchasing officer. Commission personnel also worked with the General Services Administration in revising the Federal Procurement Regulations to strengthen the subcontracting small business program for all executive agencies.

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Records Disposition

During fiscal year 1961, the Commission and its cost-type contractors disposed of 115,000 cubic feet of records having no further value, or 17,000 feet more than in 1960. About 238,000 cubic feet, representing 41 percent of all Commission-contractor records, were housed in low-cost storage areas at the end of the fiscal year.

INDUSTRIAL RELATIONS

During 1961, the following developments marked the Commission's industrial relations:

- The work force of civilian atomic energy employees in 1961 was estimated to be about 193,000 persons.
- Employment by Commission contractors dropped slightly, partially because of the cancellation of the Aircraft Nuclear Propulsion program, and completion of certain maintenance-type programs.
- Work stoppages due to labor disputes had only a minimal effect on Commission programs.
- Base earnings among the Commission's contractor work force continued to show an average annual increase of about five percent.
- The Commission reviewed, and after making some minor changes for clarity, reaffirmed its long standing contractor personnel management and labor relations policy.
- A survey showed that there are at least 14 jobs that are unique atomic energy occupations.

MANPOWER FOR ATOMIC ENERGY

Total employment [47] in 1961 for all sectors of the atomic energy field, exclusive of members of the Armed Forces is estimated to have been 193,000. Some 138,000 persons, of the total, were employed by industrial firms.

Information for two of the sectors, industrial employment and Federal service, was secured from nationwide surveys. The U.S. Bureau of Labor Statistics collected data from those industrial establishments employing atomic energy workers and the U.S. Civil Service Commission obtained the Government service data from its annual inventory of Federal personnel.

[47] This employment comprises research and production activities exclusively and directly devoted to the development of goods and services for the atomic energy field, including uranium mining, milling, enrichment of uranium, reactor manufacturing, operation of reactors, etc., and various types of nuclear research as well as training in nuclear subjects. Excluded are the actual applications of nuclear energy for transmission and consumption of electricity, and nuclear ship operation; also the use of radioisotopes merely as a tool in medical or dental practice, in an industrial process or in non-nuclear research.

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A survey of atomic energy employment in universities and colleges was undertaken by the National Science Foundation for the Commission, but data collection could not be started until the fall of 1961. All educational institutions that might possibly perform some activity in atomic energy were canvassed by mail questionnaire. At the year's end returns were still being submitted by respondents and all of the figures had not been evaluated.

Industrial Employment

According to the Bureau of Labor Statistics' study,[48] about 138,000 atomic energy workers were employed in 1961 in establishments operated by industrial firms comprised of both Commission contractors as well as non-contractors. Covered by the survey were 257 companies operating 318 establishments.

In a previous 1960 survey,[49] coverage was limited to the facilities of the Commission's major prime contractors. For 1961, however, the investigation was broadened to comprise all industrial establishments where atomic energy activity might exist. The 1960 figures included certain laboratories under the management of educational institutions which were surveyed by the Bureau of Labor Statistics. However, for 1961 some 20 of these university laboratories are included in the National Science Foundation survey, as are all of the Commission's national laboratories operated by university contractors. The Commission's national laboratories included under the educational institution survey employed close to 16,000 persons during 1960.

Engineers, scientists, and other technical workers accounted for about 31 percent of all employees in 1961. This percentage mirrors the heavy demand for highly trained professional and technical manpower in atomic energy development and production. Many skilled craftsmen were also employed, representing about 20 percent of total employment.

The activities of the surveyed establishments were divided into 15 major economic segments. On the survey questionnaire, each unit reported the nature of its dominant activity, the two largest segments being atomic energy defense production facilities and Commission laboratory and research facilities. When evaluating the relative employment by activity types in 1961 as against 1960,[50] it must be recognized as already mentioned, that the Commission's national labora-

[48] Employment in the Atomic Energy Field, A 1961 Occupational Survey. Report is being prepared for the U.S. Atomic Energy Commission by the Bureau of Labor Statistics, Dept. of Labor.

[49] See pp. 106–109, Annual Report to Congress (Jan.–Dec. 1960).

[50] Employment in the Atomic Energy Field, A 1960 Occupational Survey. Prepared for the U.S. Atomic Energy Commission by the Bureau of Labor Statistics, Dept. of Labor. Bulletin No. 1297, April 1961, Superintendent of Documents, Government Printing Office, Washington 25, D.C., $0.30.

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tories operated by university contractors are not included in the 1961 survey. This exclusion affects the relative size of the segment designated "Commission laboratory and research facilities." A new segment was also used in the 1961 classification, industrial radiography. It comprises the 61 establishments primarily using nuclear energy to provide commercial radiographic service.

Table 6 Employment by Occupation and Primary Functions, classifies the January 1961 total employment by occupational groups and primary functions. In recent years special attention has been given to the expanding "technician" category.[51]

Table 7 presents a summary of total employment by type of segment with reference to January 1960, January 1961, and the percent of change as reported in the 1961 survey. The tabulation accounts for all persons on the payroll of the reporting unit regardless of whether the employees worked full or part-time.

TABLE 6.—ATOMIC ENERGY INDUSTRIAL EMPLOYMENT BY OCCUPATION AND PRIMARY FUNCTIONS—318 Industrial Establishments in the Atomic Energy Field, January 1961 [a] (Preliminary data)

Occupation	Total employed in all functions	Performance of research-development	Management and administration of research-development	Management and administration other than research-development	Technical sales and service [b]	Production and operations	All other activities
All employees	137,566	23,636	3,104	10,169	885	75,117	24,655
Engineers	18,414	8,825	1,096	1,117	782	5,419	1,175
Aeronautical engineers	217	162	31	5	12	7	0
Chemical engineers	2,247	1,063	148	144	87	730	75
Civil engineers (architectural, construction, sanitary, etc.)	1,294	177	18	146	25	611	317
Electrical and electronic engineers	3,612	1,853	235	185	100	1,005	234
Mechanical engineers	5,760	2,742	349	389	325	1,663	292
Metallurgical engineers	772	452	94	47	35	133	11
Reactor engineers	1,621	1,207	112	26	97	165	14
Other engineers	2,891	1,169	109	175	101	1,105	232
Scientists	7,209	4,662	659	270	103	1,361	154
Chemists	2,900	1,648	249	115	31	818	39
Physicists	2,135	1,592	246	45	37	205	10
Health physicists	352	136	34	21	2	136	23
Metallurgists	633	503	61	11	7	44	7
Geologists and geophysicists	62	23	1	10	2	23	3
Mathematicians	782	554	35	46	8	89	50
Medical scientists (excluding practitioners)	48	3	2	12	2	20	9
Agricultural scientists	9	7	0	0	0	2	0

See footnotes at end of table.

[a] Evidence of this fact is shown by a handbook published by the U.S. Department of Labor entitled "Technical Occupations in Research, Design and Development Considered as Directly Supporting to Engineers and Physical Scientists," and published in February 1961. It presents information concerning job duties, skills, and required knowledge.

TABLE 6.—ATOMIC ENERGY INDUSTRIAL EMPLOYMENT BY OCCUPATION AND PRIMARY FUNCTIONS—318 Industrial Establishments in the Atomic Energy Field, January 1961 [a] (Preliminary data)—Continued

Occupation	Total employed in all functions	Performance of research-development	Management and administration of research-development	Management and administration other than research-development	Technical sales and service [b]	Production and operations	All other activities
Scientists—Continued							
Biological scientists	181	125	29	2	0	24	1
Other scientists	107	71	2	8	14	0	12
Other professional and administrative personnel	13,278	626	493	5,736	--------	4,481	1,942
Technicians	16,645	7,154	30	139	--------	7,506	1,816
Draftsman	3,889	1,029	6	56	--------	2,212	[illegible]
Electronic technicians	2,034	1,187	7	9	--------	742	[illegible]
Instrument technicians	829	488	0	2	--------	329	[illegible]
Other engineering and physical science technicians	5,913	3,531	14	8	--------	1,919	441
Health physics technicians	775	79	0	42	--------	576	78
Medical, agricultural, and biological technicians	203	41	0	3	--------	61	[illegible]
Other technicians	3,002	799	3	19	--------	1,667	514
Clerical and other office personnel	20,354	699	804	2,571	--------	6,855	9,425
Skilled trades (journeymen only)	27,239	1,074	7	56	--------	23,653	2,449
Boilermakers	515	0	0	10	--------	420	[illegible]
Carpenters	1,025	3	0	1	--------	642	379
Chemical operators	4,092	55	0	1	--------	4,036	[illegible]
Electricians	2,215	29	1	4	--------	1,857	324
Instrument makers (including experimental machinists and others who fabricate instruments	485	121	0	0	--------	348	16
Instrument mechanics (including instrument repairmen)	1,284	37	0	1	--------	1,234	12
Machinists (all-around)	4,136	343	2	8	--------	3,713	70
Maintenance mechanics (including machine repairmen and millwrights)	3,711	40	0	4	--------	3,224	443
Plumbers, pipefitters and steamfitters	1,682	25	0	1	--------	1,188	[illegible]
Sheet metal Workers	705	58	0	0	--------	541	[illegible]
Tool and die makers	847	63	4	2	--------	777	1
Welders	1,475	72	0	9	--------	1,366	[illegible]
Other skilled trades	5,067	228	0	15	--------	4,307	[illegible]
Nuclear reactor operators	865	116	7	2	--------	740	[illegible]
All other production, maintenance, and construction workers	24,144	478	4	224	--------	21,537	[illegible]
Service workers	9,418	2	4	54	--------	3,565	[illegible]
Plant protection and security	2,732	0	0	29	--------	936	[illegible]
Other service workers	6,686	2	4	25	--------	2,629	[illegible]

[a] Both private plants and Government-owned contractor-operated plants are included.
[b] Information on technical sales and service was requested for scientists and engineers only.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

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Source: U.S. Departm

Federal Service Employment

The total number of civilian personnel employed in atomic energy activities was 8,011 of which 6,766 were in the Atomic Energy Commission. Eleven agencies besides the Commission are represented, with the Navy, National Aeronautics and Space Administration, and Army reporting 561, 267, and 187 civilian workers respectively in the atomic energy field. (These data refer to October 30, 1960, the latest date for which figures were available from the Civil Service Commission's annual survey.)

All Other Employment

The following tabulation summarizes the estimates for employment in atomic energy work exclusive of that already described for industry and the Federal service:

Sector of Atomic Energy Field	*Number Employed*
Uranium mining	4,000
Private non-industrial and non-educational research and development laboratories	1,700
Construction of nuclear facilities	11,000
AEC research centers operated by universities, including supporting personnel	18,300
Other university and college research and teaching, including supporting personnel	12,000
Total	47,000

TABLE 7.—EMPLOYMENT IN 318 INDUSTRIAL ESTABLISHMENTS IN THE ATOMIC ENERGY FIELD[1] (January 1960 and January 1961)
(Preliminary Data)

Type of Activity	Number of establishments	Total Employment		Percent Change
		January 1960	January 1961	
Atomic energy defense production facilities	15	38,989	39,214	0.6
Commission laboratory and research facilities	8	23,334	22,636	−3.0
Reactor and reactor component design and manufacturing	35	18,983	18,384	−3.2
Production of feed materials	11	12,122	11,915	−1.7
Design and engineering of nuclear facilities [2]	22	9,107	9,089	−.2
Private research laboratories, including privately owned test reactor facilities, engaged in atomic energy work	33	7,921	7,981	0.8
Production of special materials for use in reactors	15	3,759	4,210	12.0
Uranium milling	24	3,618	3,851	6.4
Fuel element fabrication and recovery activities	9	2,951	2,701	−8.5
Industrial radiography	61	1,115	1,219	9.3
Particle accelerator manufacturing	4	608	761	25.2
Power reactor operation and maintenance	9	499	670	34.3
Radioactive waste disposal	7	272	280	2.9
Processing and packaging radioisotopes	15	177	210	18.6
Miscellaneous	50	13,780	14,445	4.8
Total, all activities	318	137,235	137,566	0.2

[1] Both private plants and Government-owned contractor-operated plants are included.
[2] An indeterminate amount of construction employment is included for some establishments.
Source: U.S. Department of Labor, Bureau of Labor Statistics.

Unique Atomic Energy Occupations

To meet a growing need for basic information about jobs distinctive to the atomic energy field, the U.S. Department of Labor released a study in June 1961 showing 14 such occupations. The job appraisals are included in the publication "Selected Occupations Concerned with Atomic Energy." The 14 different jobs are evaluated from the standpoint of job definition; education, training and experience; aptitudes; temperaments; and physical demands and working conditions:

Accelerator Operator	Radiation Monitor
Chemical Process Operator	Radiographer
Decontamination Man	Radioisotope Production Operator
Gamma Facilities Operator	Scanner
Health Physicist	Test Reactor Operator
Hot Cell Technician	Waste Disposal Man
Power Reactor Operator	Waste Treatment Operator

Contractor Employment

The monthly data reflecting Commission contractor employment through October 1961, shows the effect of the cancellation of the Aircraft Nuclear Propulsion program, reduced rates of process equipment revision, improved utilization of existing equipment, and completion of certain maintenance-type programs. Among 29 prime cost-reimbursable contractors operating 38 Government-owned installations, employment averaged 90,384 for the first ten months of 1961 as compared to 91,159 for the same period of 1960.

The employees in this work force, who are engaged in operations, research, development, maintenance and service, are classified into three groups—production and related workers (non-exempt manual [52]); clerical and related (non-exempt non-manual); and executive, administrative, and professional (exempt [53]). There is a continuation in the upward trend of "exempt" employees and the downward trend of "non-exempt" work force (see table 8, Average Employment at AEC-Owned, Contractor-Operated Establishments). During the ten month period January through October 1961, "exempt" employees accounted for 32.5 percent of the work force; clerical and related, 23.5 percent; and production and related workers, 44.0 percent. During the same period in 1960 the composition was 31.4 percent, 24.0 and 44.6 percent, respectively.

[52] "Non-exempt" consists of all manual and non-manual employees performing duties which meet the requirements for inclusion under the overtime provisions of the Fair Labor Standards Act.

[53] "Exempt" consists of all personnel employed in a bona-fide executive, administrative or professional capacity who are exempt from the overtime provisions of the Fair Labor Standards Act.

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TABLE 8.—AVERAGE EMPLOYMENT AT AEC-OWNED, CONTRACTOR-OPERATED ESTABLISHMENTS, EXEMPT AND NONEXEMPT PERSONNEL, 1952–October 1961

	Exempt		Nonexempt, non-manual		Nonexempt, manual		Total personnel
	Number	Percent	Number	Percent	Number	Percent	
1952	11,737	24.7	13,954	26.9	24,365	48.4	50,056
1953	15,435	24.8	17,122	27.6	29,589	47.6	62,146
1954	17,001	25.3	18,171	27.1	31,915	47.6	67,087
1955	18,475	24.5	19,840	26.3	37,248	49.3	75,563
1956	20,682	25.7	20,574	25.5	39,367	48.8	80,623
1957	23,679	27.7	22,173	25.8	39,885	46.6	85,737
1958	26,301	29.6	21,533	24.2	41,162	46.2	88,996
1959	27,550	30.2	22,046	24.1	41,708	45.7	91,304
1960	28,681	31.5	21,791	23.9	40,609	44.6	91,081
1961*	29,366	32.5	21,277	23.5	39,741	44.0	90,384

*10-month average.

Contractor Employee Earnings

During January–October, 1961, exempt salaried personnel (executive, administrative, and professional employees) averaged $828 per month in base earnings. Over the past ten years, the salary level of this group advanced at an average rate of 5.4 percent per year. For the same period, the average rate of increase annually for salaries paid to non-exempt clerical and related employees was 4.8 percent. These employees averaged $479 per month in straight-time earnings during January–October 1961. (See Chart AEC Contractor Base Monthly Earnings.)

Since 1952, earnings of the manual work force have been compared with those of Manual Workers producing products of petroleum and coal, and industrial inorganic chemicals, the two most comparable industrial activities. The annual average straight-time manual employee hourly earnings of the Commission's contractors have followed a path between those for the two industries during the entire period (see chart, Manual Workers' Straight-Time Average Hourly Earnings). In August 1961 (latest available data), the actual level of manual workers' straight-time pay averaged $2.96 per hour for Commission contractor employees, $2.96 per hour for petroleum and coal, and $2.77 for inorganic chemicals. In terms of annual increase, contractor manual employee earnings since 1952 have advanced at the average rate of 4.9 percent as compared to those of 4.8 percent for inorganic chemicals and 4.5 percent for those of the petroleum industry.

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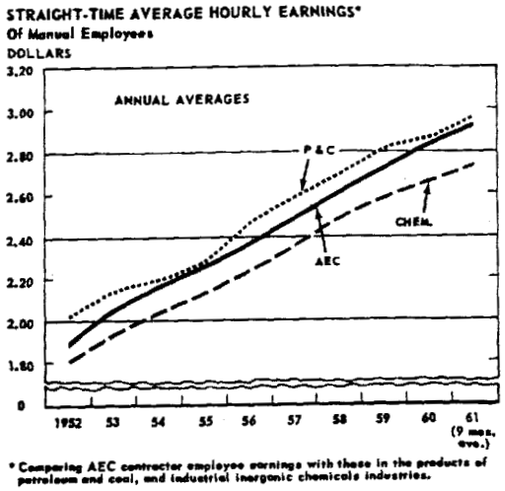

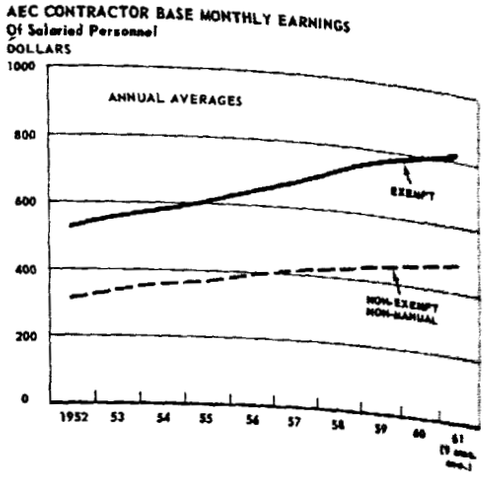

Fringe Benefit Payments to Manual Workers

Data from the 1960 survey of fringe-benefit payments received by manual workers employed by Commission contractors indicate a continued increase in this type of labor cost. In terms of cents per payroll hour, these benefits rose from 52.2 cents in 1958, to 59.9 in 1960. This upward climb was in contrast to the downward movement in premium pay. For 1960, out of every dollar paid for total hourly labor cost, 18.6 cents represented fringe benefits.

Table 9 presents the components of fringe benefits for the years 1958–1960 as paid by Commission contractors. It also shows the relation of these benefits to total hourly labor cost; premium pay; and pay for time worked (excluding premium pay).

Table 9.—Estimated Fringe Benefits Paid to Manual Workers [a]

Type of Payment	*Cents Per Payroll Hour*		
	1958	*1959*	*1960*
Total Labor Cost Per Hour	2.949	3.084	[illegible]
Pay for Time Worked (excluding premium)	2.286	2.397	[illegible]
Premium Pay	.141	.126	[illegible]
Fringe Benefits	.522	.561	[illegible]
Components of Fringe Benefits:			
Payments for Time Not Worked	.281	.296	[illegible]
Voluntary Payments	.151	.162	[illegible]
Legally Required Payments	.085	.098	[illegible]
Other Items	.005	.005	[illegible]

[a] Source: Annual AEC Contractor Fringe Benefits Survey of Manual Employees.

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The largest fringe-benefit component is that designated "Time Not Worked" which includes such items as paid rest and lunch periods; vacation, holiday, and sick leave pay; jury duty and military leave. Next in order is "Voluntary Payments" represented by such payments as: pension plan and life-insurance premiums; sickness, accident and hospital insurance; savings and investment plans. "Legally Required Payments," the third group, comprises those payments required by governmental statute; and the fourth segment, "Other Items," is intended to reflect such payments as profit sharing and special bonuses. Each of these components, with the exception of "Other Items" which remained stationary, contributed toward the upward trend in total fringe benefits.

LABOR-MANAGEMENT ACTIVITIES

Collective Bargaining

About 68 percent of the 39,166 non-exempt manual work force reported by the Commission's 29 cost-type contractors in July 1961 were represented by labor unions under collective bargaining agreements. The following table shows the distribution of labor organizations and the approximate number of employees represented.

	Approximate Representation	*Percent*
Metal Trades Councils (AFL–CIO)	12,711	47.8
Int'l. Assoc. of Machinists (AFL–CIO)	5,999	22.6
Oil, Chemical & Atomic Workers Int'l. Union (AFL–CIO)	4,344	16.3
Misc. Unions (Excl. guards, but incl. crafts, etc.)	2,314	8.7
Misc. Guards Unions (independent unions)	1,210	4.6
	26,578	100.0

Labor union representation among the office and clerical work force covered 6.4 percent of approximately 21,400 employees.

	Approximate Representation
Office Employees International Union (AFL–CIO)	1,290
Schenectady Draftsmen's Association (Independent)	85
	1,375

General Industrial Relations Problems

Work Stoppages

Few work stoppages occurred in Commission operations activities during 1961. During the first 10 months of the year operating con-

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tractor employees worked a total of 167,638,000 hours with lost time of 35,900 hours, for a total effect of only 0.02 percent of time lost due to work stoppages. During this same period, bargaining activity affected approximately 16,000 employees in the course of 37 negotiated settlements resulting from initial contracts, renewals, and re-openers.

Three work stoppages involved operating contractors. Of longest duration was the ten-week strike involving the 95 union-represented employees of Mason and Hanger-Silas Mason Co. at Clarksville, Tenn. The strike which began early in May and ended on July 17, resulted from a dispute involving the wage provisions of an initial contract between the contractor and the International Association of Machinists. No special mediation efforts to resolve the dispute were made by the Atomic Energy Labor-Management Relations Panel. The strike did not adversely affect the Commission programs.

During the month of July, a 15-day strike occurred at the Nevada Test Site (NTS) involving the plumbers and pipefitters employed by Reynolds Electrical and Engineering Co. on both construction and operating activities and other NTS construction contractors, including those engaged on the ROVER and PLUTO projects which were adversely affected by the stoppage. The dispute involved the Master Plumbers Association of Clark County, the Association of General Contractors of Nevada, and the Plumbers and Pipefitters Union. Work was resumed on the basis of an interim agreement pending final resolution by the National Labor Relations Board (NLRB) of an issue regarding bargaining representative rights and responsibilities as between the two employer associations. Final resolution of this issue is still pending before the NLRB.

A contract renewal dispute between the Fernald Atomic Trades and Labor Council (AFL–CIO) and the National Lead Co. of Ohio resulted in a four-day strike (partly a weekend) in October at the Commission's Fernald, Ohio, site. The strike was called off upon intervention of the Atomic Energy Labor-Management Relations Panel.

Panel Activities

During 1961, the Atomic Energy Labor-Management Relations Panel took action in four cases involving: the Brookhaven National Laboratory and the Directly Affiliated Local No. 24426; Sandia Corp. and the Atomic Projects and Production Workers, Metal Trades Council; Sandia Corp. and the Office Employee International Union, and National Lead Co. and the Fernald Atomic Trades Labor Council. The Panel continued to keep fully informed on other collective bargaining developments in the Commission's programs and met fre-

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EQUAL EMPLOYMENT OPPORTUNITY

On March 6, 1961, President Kennedy signed Executive Order 10925, Part I of which established the President's Committee on Equal Employment Opportunity. The Executive Order became effective on April 7, 1961. The Order states that discrimination because of race, creed, color, or national origin is contrary to the constitutional principles and policies of the United States and that it is the plain and positive obligation of the United States Government to promote and ensure equal opportunity for all qualified persons, without regard to race, creed, color or national origin, employed or seeking employment with the Federal Government and on Government contracts. Part II of the Order covers non-discrimination in Government employment while Part III states the obligations of Government contractors and sub-contractors.

In a memorandum addressed to all Commission contractors and sub-contractors dated May 2, 1961, Chairman Seaborg stated: "I earnestly call upon all AEC contractors and sub-contractors to comply wholeheartedly not only with the specific provisions of the President's Order, but also with its spirit and intent. We in AEC are determined to firmly and fully support the objectives of the President's Order in the belief that it is our obligation to ensure equal employment opportunity for all persons."

The new contract clause required by the Executive Order is being inserted in all contracts to which it is applicable and the following material published by the President's Committee has been distributed to all Commission field offices for their use in administering the Order:

a) A booklet "Equal Employment Opportunity in Federal Government on Federal Contracts," which quotes the text of the Executive Order and lists the members of the President's Committee.
b) Order No. (C–1) dated June 12, 1961, which prescribes a standard non-discrimination poster to be posted by contractors as required.
c) Order No. (C–2) dated June 12, 1961, which establishes the procedure for the furnishing of notices by contractors to labor unions or other organization of workers as required.
d) A booklet "Government Contract Employment Rules and Regulations of the President's Committee on Equal Employment Opportunity," under which the aims set forth in Part III of the Order will be achieved.

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The Atomic Energy Commission Procurement Regulations, Subpart 9–12.52, Nondiscrimination in Employment, are being amended to incorporate the requirements of the new Executive Order.

Missile Site Labor Commission

On May 26, 1961, the President signed Executive Order 10946 establishing a program relating to labor disputes at missile and space sites. An eleven-member Missile Site Labor Commission (MSLC) was created, consisting of the Secretary of Labor, the Director of the Federal Mediation and Conciliation Service, three representatives from the public, three representatives from labor, and three representatives from management. The MSLC has the responsibility for developing policies, procedures and methods of adjusting labor problems at missile and space sites and is granted authority to arrange for the appointment at missile or space sites of appropriate Missile Site Labor Relations Committees. These Committees are to anticipate impending problems and to arrange for their proper disposition before they become acute.

There is a close interrelationship of activities, contractors, and employees at the Atomic Energy Commission's ROVER and PLUTO test facilities with those of other non-space and non-missile work at the Nevada Test Site (NTS). Their activities are carried out under the established policies and procedures of the AEC Procurement Regulation 9–12.51 and AEC Manual Chapter 4205–05. As a result, the Missile Site Labor Commission has not, as yet, activated a local Missile Site Labor Relations Committee at the ROVER-PLUTO test facilities. However, the Atomic Energy Commission is taking appropriate action to assure that the objectives of Executive Order 10946 are fully understood and will be carried out by the persons responsible for the progress of the work at the ROVER-PLUTO test facilities on a day-to-day basis.

Labor Relations Policy Reaffirmed

During the latter half of 1961, the Commission undertook a review of its labor policy in light of current conditions. The resulting reaffirmation made no substantial changes in the policy which has been virtually unaltered for 12 years. However, with a view toward clarification of the published policy certain minor improvements were made:

a. The new policy statement recognizes the increasing importance of the Commission's laboratory and research activities.

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[a] See pp. 146–148,
(January–June 1957)

With respect to wages, salaries and employee benefits, the Commission's role in the review of bargaining over these items has been clarified, and new language has also been added which further encourages the adoption of practices promoting orderly collective bargaining relationships. The Commission reserves the right to object to practices inconsistent with this objective.

In addition, the statement regarding working conditions has been expanded to give greater emphasis to safety and the employer's responsibility to sponsor programs designed to prevent accidents and maintain health.

AEC Procurement Regulations Part 9–12 Labor

Contracting agencies are responsible for administering certain aspects of the Convict Labor, Walsh-Healey, Davis-Bacon, Copeland, and Eight Hour Laws, and the executive order on non-discrimination in employment. Coordination of the agencies which administer these laws is the responsibility of the Secretary of Labor, while the nondiscrimination Executive Order is coordinated by a President's committee which is chaired by the Vice President. The administration of other labor standards laws (i.e., Fair Labor Standards Act, Taft-Hartley Act, etc.) is not primarily the responsibility of contracting agencies, but comity and the prudent expenditure of Government funds require that some attention also be paid to these laws as a part of contract administration.

In its Twenty-second Semiannual Report [54] the Commission stated it was experiencing difficulty in carrying out its responsibilities under the Davis-Bacon Act, particularly in distinguishing plant maintenance work, which is not covered by the Act, from construction, alteration or repair work, which is covered, and that an intensive study was underway to improve the situation. Actually, the problem is more complex than was indicated in 1957. It embraces operational as well as maintenance activities and has been aggravated by labor disputes involving similar problems on missile and satellite work of other agencies. The increased emphasis of the Commission in the research and development area also provides increased exposure to a source of Davis-Bacon related problems. Research and development activity involves experimentation which is carried on in equipment assemblies that range from tabletop set-ups of glassware to the large installations of steel, wire, concrete, pipe, etc., that make up an accelerator or a missile or satellite firing base. While indicia such as size, permanence, fixation to real estate, etc., are helpful as guides, there is no easy way to draw

[54] See pp. 146–148, Twenty-second Semiannual Report of the Atomic Energy Commission (January–June 1957).

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a line which classifies certain of such work as experimental development (i.e., non-covered) and other of it as construction, alteration or repair of a public work (i.e., covered). Competition for assignment to large segments of such work (i.e., jurisdiction) is intense as between certain classes of workers. For instance, scientists and engineers assigned the planning and experimentation responsibility for a given study may feel strongly that they themselves, assisted only by helpers of limited (although specialized) training and skill, should do such work as rigging, alignment, assembly, making of utility connections, etc. Construction contractors and construction unions may feel equally strongly (if large and complex equipment is involved) that all craft work belongs to them by tradition, by virtue of the broader training and competence of the journeyman as compared to the helper-technician, by Appropriation Acts which may specify the use of construction funds, and particularly by operation of the Davis-Bacon Law through the wage determination practices followed in its administration.

After the intensive study mentioned above, the Commission on January 25, 1961, published in the *Federal Register*, Part 9–12, Labor of the AEC Procurement Regulations. Subpart 9–12.50 adopts, for the first time, a standard contract clause relating to the Davis-Bacon Act for use in contracts with operating contractors who sometimes sub-contract covered work. It clarifies the procedures for obtaining wage predeterminations and their use, and more specifically emphasizes the Commission's Field Office Manager's responsibility for making coverage decisions and otherwise assuring compliance. Criteria to be used in classifying covered and non-covered work have been expanded and simplified. A new section has been added which discusses the applications of the Davis-Bacon Act to particular situations in Commission activities. In this respect, considerable attention has been given to differentiating between non-covered set-up of devices and/or processes and such covered activity as the building of prototypes, the construction of facilities within which experiments are to be conducted, etc.

Simultaneously, other subparts of the AEC Procurement Regulations have been developed dealing with Convict Labor, Eight Hour Law (other than construction), Non-Discrimination in Employment, Walsh-Healey Public Contracts Act, Fair Labor Standards Act of 1938, and Special Considerations Affecting Construction Laborers and Mechanics on Commission projects. These other subparts largely represent only a conversion to AEC Procurement Regulations of AEC Manual Chapter 4228, and the construction labor section of AEC Manual Chapter 4220.

Because workability required acceptance of the Subpart 9–12.50 criteria by those involved in jurisdictional type Davis-Bacon disputes,

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was necessary to develop this subpart largely by a process of negotiation and agreement. The Building and Construction Trades Department, Metal Trades Department, International Association of Machinists, and Oil, Chemical and Atomic Workers all participated actively in the development of these regulations. The Building and Construction Trades Department established a special committee to work with the Commission which proved to be particularly helpful.

OPERATIONAL SAFETY

Safety Awards

National Records

The 1960 President's Safety Award, given annually for accident prevention work among civilian employees of the Federal agencies, was won by the Atomic Energy Commission. Previously, the award was won in 1957 and 1959.

The Commission and its contractors, together, also won the National Safety Council Award of Honor for reduction of work injuries during 1960; this award was previously won in 1955. The Commission-contractors had an injury frequency rate of 1.71 as compared with 6.04 in all other industries reporting to the National Safety Council. Early in 1961, however, three men lost their lives in the Commission's first fatal reactor accident (SL-1).

New Commission Facility Record

On September 29, 1961, the Dow Chemical Co., contract operator of the Commission's facility at Rocky Flats, Colo., received the Atomic Energy Commission Manager's Best Record Award for establishing a new all-time Commission-contractor record of over 15 million consecutive man-hours without a disabling injury, beginning from September 17, 1957—and presently continuing—during a period of over four years. The facility, on September 13, 1961, surpassed the record of Sandia Corp., Albuquerque, N. Mex., of 14,936,169 consecutive man-hours without a disabling injury. Sandia had won the Manager's Award in 1960.

Health and Safety Appraisal Program

To further the safe operation of the production plants and research laboratories under the control of the Commission, emphasis has been

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Safety Award. For the third time in four years, the President's Safety Award was won by the Commission for the year 1960. The award is given annually for accident prevention work among civilian employees of Federal agencies. The Commission had previously earned the award in 1957 and 1959. Photo shows Secretary of Labor Arthur Goldberg (left) presenting the award, on behalf of President Kennedy, to AEC Chairman Glenn T. Seaborg.

increased on surveillance of the health and safety activities supervised by the Commission's field offices. Reviews are being made of the staff, organization and performance, and the capability of the field offices to assure contractor compliance with the Commission's health and safety requirements. As a part of this program, the Commission, during 1961, amended its reactor operations contracts to delineate better the contractor's responsibilities with regard to reactor safety procedures. (See section on Contracting Policy in this report.)

Such functions as industrial safety, hygiene and medicine, radiation protection, and fire protection are now being subjected to evaluation by the professional staff of the Commission's Division of Operational Safety. As a result of the Commission's recent reorganization, the responsibilities of that division have been increased to include preparation of safety guides and standards for, and the evaluation of, the

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fety surveillance program for Commission-owned reactors, waste isposal, and safety in the handling and storage of fissionable aterials.

erious Accidents

During the year November 1, 1960 to November 30, 1961, there were 3 reportable accidents in the Commission's atomic energy facilities. There were 3 deaths or injuries attributable to accidents involving adiation and 16 deaths or injuries not involving radiation. Table 10 summarizes those accidents that are considered as serious enough o be immediately reported to Commission headquarters. (AEC Manual Chapters 0502–04 and 0523–052 give the definitions of immediately reportable accidents.)

TABLE 10.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]

November 1, 1960—November 30, 1961

HS No.[b]	Date	Operations office [c] and contractor	Injury and overexposures	Loss	Remarks
60-31	11- 8-60	AL—Sandia Corp.	2 overexposures.	0	Employees were accidentally exposed to electron beam emanating from a Van de Graaff accelerator. One received total estimated dose, 2305 rads to face, 12,340 rads to hands; the other employee 53 rem whole body.
60-34	11- 2-60	SR—E.I. du Pont de Nemours & Co.	0	$37,100	Fire in a construction building.
60-35	11-10-60	SAN—University of California (Livermore Radiation Laboratory)	0	$186,000	Fire started in curium processing cave by an apparent overheating of oil bath in glove box. Loss confined to one room, but all contents complete loss. No release of radioactive materials to environment.
60-36	11-10-60	SR—E.I. du Pont de Nemours & Co.	0	$40,000	Induced-draft fan of a boiler failed due to excessive vibration.
60-37	11-14-60	AL—Sandia Corp. (Subcontractor; Wurlitzer Corp., North Tonawanda, N.Y.)	0	$32,000	Fire occurred in processing room.
60-38	12- 7-60	OR—Union Carbide Nuclear Co.	0	$10,036	A loaded, high-pressure, 30-tube gas trailer overturned in the process of coupling to tractor. (Material loss, $8,886; truck damage, $1,150).

See footnotes at end of table.

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TABLE 10.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]—Continued

November 1, 1960—November 30, 1961

HS No.[b]	Date	Operations office [c] and contractor	Injury and overexposures	Loss	Remarks
60-39	11-18-60	HA—General Electric Co.	1 injured	0	Pipefitter slipped and fell 12 feet down a shaft; he is now in a nursing home, totally disabled.
60-40	12-21-60	HA—General Electric Co.	0	$12,294	Buildup of pressure in a steam autoclave resulted in a blowoff which sent some nonradioactive material from the autoclave through the building roof.
60-41	10- 4-60	AL—Edgerton, Germeshausen & Grier	1 overexposure.	0	An employee was overexposed to gamma radiation from 340-curie cobalt 60 source, receiving 18 rem.
60-42	11-17-60	OR—Union Carbide Nuclear Co.	0	$103,260	Ten-ton cylinder of UF_6 ruptured.
60-43	11/8-28-60	OR—National Lead Co. of Ohio	0	$10,000 to $35,000	During the period November 8-20, approximately 1,500 pounds of slightly enriched uranium tetrafluoride lost through stack of dust collector located in the plant.
61- 1	1- 3-61	ID—Combustion Engineering, Inc.	3 killed [e] 9 overexposures	$1,300,000	Explosion within the reactor vessel of SL-1 reactor plant. Two members of the crew were killed instantly by explosion. The third died within about two hours as a result of an injury to the head. Maximum overexposures to nine emergency crew members during the emergency was 27 rems to two persons.
61-2	1- 9-61	AL—ACF Industries	0	$27,060	A fire in a plating shop
61-3	1-11-61	AL—Reynolds Elec. & Engineering Co.	0	$8,000	Tory II.—A test vehicle being towed from test bunker to disassembly building with a prime mover accidentally uncoupled and the vehicle car crashed into the face of test bunker, damaging the car and the bunker.
61-4	1-24-61	AL—Los Alamos Scientific Laboratory.	1 killed 0	0	An employee fell from a bunker 10-12′ to a concrete pad.
61-5	2- 2-61	AL—ACF Industries, Inc.	1 killed 0	$2,500	Head-on motor vehicle collision.
61-6	2-14-61	AL—Los Alamos Scientific Laboratory.	1 killed 0	0	Employee overcome by solvent vapors while working in an enclosure.

See footnotes at end of table.

TABLE 10.—ACCID

HS No.[b]	Date	O
61-7	1-25-61	ID— Co
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61-9	3-16-61	PNR
61-10	5-11-61	AL— cal La
61-11	1-10-61	SR— Ne
61-12	5-19-61	OR— Co
61-13	7-11-61	SAN- Cal
61-14	7-18-61	HA— Co.
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61-16	8-14-61	HA— Co.
61-17	8-14-61	SNR- tric

See footnotes at end o

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TABLE 10.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]—Continued

November 1, 1960—November 30, 1961

AIS No.[b]	Date	Operations office [c] and contractor	Injury and overexposures	Loss	Remarks
61-7	1-25-61	ID—Phillips Petroleum Co.	0	0	Criticality accident occurred at chemical processing plant, when U235 solution accidentally surged from a geometrically safe container to an unsafe vessel leading to the momentary occurrence of a chain reaction. There were no overexposures.
61-8	3-10-61	OR—Central Illinois Tower Maintenance Co.	1 killed 1 injured	0	Two employees fell 145′ when the top section collapsed during the erection of a tower.
61-9	3-16-61	PNR—Eichleay Corp	1 killed 3 injured	0	A scaffold arrangement rigged for painting the overhead structure and ceiling of a shop collapsed, causing the death of one and injuries to three, one seriously.
61-10	5-11-61	AL—Monsanto Chemical Co. (Mound Laboratory).	1 overexposure	$5,159	Pressure buildup in a closed caustic scrubber system forced airborne radioactive material into room. Employee received 2.05 times maximum permissible body burden. Area contaminated.
61-11	1-10-61	SR—E. I. du Pont de Nemours & Co.	0	$7,750	An overhead machine used to discharge reactor components struck an aluminum I-beam used to support a portable bridge.
61-12	5-19-61	OR—Goodyear Atomic Corp.	0	$37,130	Air circuit breaker failed resulting in shutdown of seven cells.
61-13	7-11-61	SAN—University of California (LRL).	0	$13,500	Fire occurred involving approximately 190 pounds of chemical explosive.
61-14	7-18-61	HA—General Electric Co.	0	$5,900	Two Hanford railroad locomotives collided head on.
61-15	8-1-61	HA—Hanford Operations Office.	0	$8,000	Range fires burned approximately 4,300 acres, probably caused by sparks from a defective muffler on railroad diesel locomotive.
61-16	8-14-61	HA—General Electric Co.	1 killed 0	0	Employee fatally injured when tractor rolled backwards out of control while he was assisting in unloading it from a trailer.
61-17	8-14-61	SNR—General Electric Co.	0	$5,700	Fire burned approximately 3,000 square feet of newly laid roof, causing damage to the building and ventilating equipment located on the roof.

See footnotes at end of table.

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TABLE 10.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]—Continued

November 1, 1960—November 30, 1961

HS No.[b]	Date	Operations office [c] and contractor	Injury and overexposures	Loss	Remarks
61-18	8-29-61	AL—Sandia Corp.	0	$14,700	Flash flood at deactivated base. Removal of 8-12 inches of silt majority of cost.
61-19	9- 2-61	ID—Phillips Petroleum Co.	0	$18,500	Compressor malfunctioned, damaging insulation and wiring on stator and rotor.
61-20	9- 7-61	AL—Los Alamos Scientific Laboratory.	1 killed	0	Employee killed in a motor vehicle accident in which car skidded and turned over.
61-21	8-14-61	HA—Hanford Operations Office.	0	$69,865	Series of brush fires caused by a violent electrical storm.
61-22	9-13-61	AL—Bendix Corp.	0	$550,000	Flood following Hurricane Carla.
61-23	10-2/24-61	SR—E. I. du Pont de Nemours & Co.	0	Not known	Series of flume failures occurred in SRP Reactor Cooling Water Effluent System.
61-24	10-25-61	AL—Dow Chemical Co.	0	$5-6,000	Explosion (considered to be of low order) occurred in boiler.
61-25	10-26-61	AL—Sandia Corp. (subcontractor: Wurlitzer Corp., North Tonawanda, N.Y.)	0	$237,000	Fire in dry room.
61-26	10-20-61	AL—Monsanto Chemical Co.	1 overexposure	$590	Polonium contamination to employee of 1.4 body burden when glass apparatus containing polonium was dropped. Small amount of room contamination readily cleaned up.
61-27	10-29-61	AL—Government	0	$125,000	Airplane struck 500-foot radio tower, collapsing tower. Wing torn from plane.
61-28	11- 7-61	AL—ACF Industries, Inc.	4 injured	0	Gas explosion in portable metal shed housing reactor. Four employees received minor injuries. Shed badly damaged, piping and equipment exterior to reactor also damaged.
61-29	1-2/27-61	OR—Oak Ridge National Laboratory.	1 overexposure	0	Employee received beta burns to hands and fingers on at least two occasions while performing operations on fuel specimens. The dose estimates were 1200 rad to fingers of left hand and 900 rad to fingers of right hand.
61-30	10-15-61	ID—Phillips Petroleum Co.	0	$10,000	Contractor's bus collided with private car; 20 bus passengers received minor injuries. Private car driver killed.

See footnotes at end of table.

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TABLE 10.—ACCIDENTS REPORTED IN AEC OPERATIONS [a]—Continued

November 1, 1960—November 30, 1961

HS No.[b]	Date	Operations office [c] and contractor	Injury and overexposures	Loss	Remarks
61-31	9-18-61	ID—Naval Reactor Testing Station.	0	$7,525	Flood damage.
61-34	8-16-61	HA—J. A. Jones Construction Co.	0	$5,100	Contamination spread occurred while dismantling old laboratory equipment in a process building. Five employees received some skin contamination.

[a] Criteria for Immediately Reportable Accidents and Radiation Overexposures.

I. *Accidents:* (a) Injury or illness of an AEC contractor employee, or a member of the public, where such injury or illness could be attributed to AEC or AEC contractor operations, and which results in: (1) death or imminent death of one or more persons, or (2) injury or illness to five or more persons as the result of one accident; (b) Any accident that the responsible Field Manager or Headquarters Division Director believes to have public information significance; (c) Estimated loss or damage of $5,000 or more of Government property, or estimated costs of $5,000 required for cleaning, renovating, replacing or rehabilitating structures, equipment or property.

II. *Radiation Overexposures:* (a) An injury or illness, diagnosed by a physician, competent in nuclear medicine, as probably resulting from a cumulative or massive exposure to ionizing radiation; (b) A single exposure received over a short period of time in which: (1) the external whole body penetrating radiation exposure is greater than 12 rems, (2) the radiation exposure dose to the skin of whole body or thyroid is greater than 30 rems, (3) the external radiation exposure dose to the hands and forearms or feet and ankles is greater than 75 rems, or (4) the internal body deposition when averaged over a period of one year exceeds the radiation protection guide; (c) Any radiation exposure which causes an individual's accumulative dose to exceed 5(N–18) rems whole body radiation; (d) Whenever there is reason to believe that any member of the general population off-site may have received, as a result of AEC or AEC contractor activities, a radiation exposure greater than those specified for external or internal exposure by Chapter 0524; (e) Any overexposure that the responsible Field Manager or Headquarters Division Director believes to have public information significance. (Several exposures occurred during 1961 operations at the Nevada Test Site (see footnote, page 162) but are not shown in the table above because they did not fall within the above criteria.)

"Public information significance," as used herein, means that members of the general public might receive information of an event resulting from AEC or AEC contractor activities which would be regarded, rightly or wrongly, as detrimental to the health and safety of humans, plants, animals or property. Note: Complete investigation is made of each accident or radiation overexposure reported under the above criteria, and appropriate action is taken to limit the loss or damage in each case and to prevent recurrence of similar accidents or overexposures.

[b] During 1961, the Commission's Office of Health and Safety was reorganized and renamed Division of Operational Safety; the old "HS" file number was retained for these reportable accidents.

[c] Operations Office abbreviations in this table:

AL—Albuquerque
HA—Hanford
ID—Idaho
OR—Oak Ridge
PNR—Pittsburgh Naval Reactors
SAN—San Francisco
SNR—Schenectady Naval Reactors
SR—Savannah River

[d] Nos. HS 60-32 and HS 60-33 were previously reported; see page 271, Annual Report to the Congress (January–December 1960).

[e] Also being reported by the military.

WORK INJURIES IN AEC OPERATIONS

The rate of disabling work injuries in the Commission's operations increased 15 percent during 1961—from 1.71 per million man-hours worked, to 1.97. This was 68 percent below the 1960 National Safety

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Council (NSC) all-industry average, and ranked fourth safest among the industry groups reporting to NSC. (Data for 1961 not yet available for NSC average.) There was an increase in the number of fatal accidents from four in 1960 to 10, as of November 1, 1961. This includes three deaths in the SL-1 reactor accident at Idaho Operations Office on January 3, 1961, which are also being reported by the military. Three of the other seven fatalities were caused by falls, two by motor vehicle, one when a fabrication technician was overcome by solvent fumes while cleaning a tank, and one by an employee being crushed when a tractor rolled backwards out of control while being unloaded.

AEC INDUSTRIAL INJURY FREQUENCY RATES [a]

	1960	January–November 1961	Percent increase or decrease
Production	0.73	0.94	+ 29
Research	1.57	1.83	+ 17
Services	2.30	2.65	+ 15
Cost-Plus Construction	4.23	4.73	+ 11
Lump-Sum Construction	13.35	13.36	+0.1
Architect-Engineering	1.48	0.96	−69
Government	0.69	1.56	+126
All	1.71	1.67	+ 15

[a] Number of lost-time injuries per million man-hours.

MAJOR PROPERTY DAMAGE AND LOSS BY FIRE AND EXPLOSIONS DURING 1961

Fire:			
HS-61-2	1- 9-61	Electrical Fire	$27,060
HS-61-13	7-11-61	High Explosives Fire.	13,500
HS-61-15	8- 1-61	Range Fire	8,600
HS-61-17	8-15-61	Roof Fire	5,700
HS-61-21	8-14-61	Range Fire	69,865
HS-61-25	10-25-61	Dry Room Fire	237,000
Explosion:			
HS-61-1	1- 3-61	Reactor SL-1	1,300,000
HS-61-24	10-25-61	Boiler	8,000

Radiation Exposure of AEC Contractor Personnel [55]

In the course of their work, some employees at atomic energy installations may receive some exposure to radiation. Annual surveys among the Commission's contractor employees show that of the more than 82,000 monitored in 1960, 99.9 percent received less than five rems within a year, and that 94.5 percent received only

[55] Radiation exposures among employees of Commission licensees are reported under the Safety and Compliance section of Part 3.

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one rem or less. These exposures, except those which are specifically cited elsewhere in this report, are well within the limits as recommended by the Federal Radiation Council for atomic energy workers. The following table gives details for the year 1960 (latest date available):

EXPOSURE OF AEC CONTRACTOR PERSONNEL TO PENETRATING RADIATION

Range of annual total exposure in rems [a]	*Number of workers*	*Percent of total No. of workers*
0-1	77, 522	94. 31
1-5	4, 629	5. 63
5-10	41	. 05
10-15	2	---------
Above 15	[b] 3	---------
Total	82, 197	

[a] The rem is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen of high voltage X-rays.
[b] See Serious Accidents HS-60-31 and HS-60-41.

Environmental Monitoring

The Commission issues periodic reports of the levels of radioactivity in the environment around its production plants, laboratories, and experiments. These data are furnished to the U.S. Public Health Service for publication. Beginning on July 1, 1960, the Commission also began distributing the local reports to the news media and to state and municipal officials in the geographical areas adjacent to its facilities. The release of such information keeps the public advised as to the levels of radioactivity in the environment attributable to the operations of the Commission's plants and laboratories and helps allay public fears in this regard.

Special Hazards Under Study

Criteria For Respiratory Protective Equipment

The widespread use of radioactive nuclides and such toxic materials as beryllium has created a demand for a more efficient respirator than those labeled "for particulates no more toxic than lead" which are presently approved by the U.S. Bureau of Mines for use in industry. (The Bureau of Mines exercises Federal supervision over the adequacy and types of respirators, gas masks, etc., used in Government and industry.) In response to the Bureau's request for assistance, the Commission formed an ad hoc committee, composed of industrial

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hygienists from Los Alamos Scientific Laboratory, Hanford Plant, Rocky Flats Plant, Oak Ridge National Laboratory, Savannah River Plant, Bettis Atomic Power Laboratory, and the AEC's Health and Safety Laboratory, to aid in the promulgation of criteria for a new class of respirators which will meet the requirements of the atomic energy industry. The suggested requirements "for respiratory protective equipment for use in atmospheres containing particulates significantly more toxic than lead" were submitted by the committee to the Bureau of Mines in July 1961.

As a corollary to the development of criteria for respirator performance the Commission has also supported a research project at the Harvard School of Public Health aimed at the development of a simple, rapid, sensitive method for testing the overall penetration of respirators. The development of this method and associated techniques is essentially complete and has been made available to the Bureau of Mines for evaluation.

Contamination Containment in Glove Boxes

Glove boxes are closed, and normally ventilated, compartments with rubber gloves sealed in the side to permit manual conduct of work with radioactive materials under conditions minimizing risk of spreading radioactive contamination to external areas. Recognizing that glove box integrity could be endangered by fire, explosion, and other causes, the Commission appointed a committee in 1959 to review experience and practice in glove box design, and a consultant was hired in September 1960 to devote full time to study of the problem. Results of the study and the committee's recommendations will be submitted to the Commission in early 1962.

High Efficiency Filters

High efficiency filters on air ventilating systems frequently serve as the final means for preventing inadvertent spread of radioactive contamination to external environs. However, because many filters failed to meet the requirements for effective removal of radioactive particulates, the Commission, in 1959, initiated work to improve air pollutant filtration. As a first step toward increasing this protection, filters of improved fire resistance were developed and found immediate, widespread use during the past two years. The importance of filters to the Commission's hazard control program, coupled with the finding that many filters received by the Commission and its contractors failed to meet design specifications, led to establishment, during 1959, of a program for testing filters before installation in

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Commission facilities. During 1961, studies were initiated on the filter test equipment and procedures used by manufacturers as a step toward correcting this situation. Additional studies are also underway to develop: (*a*) filter media having higher temperature resistance, (*b*) specifications for filters having improved resistance to physical damage, (*c*) improved adhesives for bonding filter media to the frames, and (*d*) techniques for in-place filter testing.

Metal Pyrophoricity

A number of occurrences have been experienced where such metals as uranium, plutonium, thorium, and zirconium have displayed unusual and sometimes violent fire or explosive tendencies. For example, during 1960, tests indicated that the deteriorated (18 out of 20,000) uranium fuel plates for Argonne National Laboratory's Zero Power Reactor No. 3 (ZPR–III) could be ignited at 115° C. while undeteriorated plates ignited at 480° C. By contrast to this finding, fatal injuries resulted from an apparently spontaneous explosion during the same year in privately owned zirconium scrap. Research to explain the causes of such incidents and to develop a means for preventing or controlling them is underway with emphasis on study of metal reactions with oxygen, air, and water under a wide variety of conditions.[56] The complexity of the problem is such that it has been necessary that the bulk of the work to date be devoted to basic research which will serve as a foundation for actually solving the problem.

The nature of research now underway at Argonne National Laboratory is reflected in the following titles of individual projects:

a. "Isothermal Oxidation Kinetics of Reactor Metals"
b. "Mechanism of Oxidation of Reactor Metals"
c. "Development of Techniques for Measurement of Ignition Properties of Reactor Metals"
d. "Determination of Ignition and Burning Temperatures of Reactor Metals"
e. "Determination of Velocity of Burning Propagation of Reactor Metals"
f. "Determination of Ignition Behavior of Metal Powders"
g. "Development of Theoretical Concepts of Metal Ignition"
h. "Development of Extinguishing Agents for Reactor Metal Fires"

Final Report SRIA–29, issued August 15, 1960, and entitled "A Study of Spontaneous Ignition of Metals,"[57] details conclusions of

[56] The Commission's special report, "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Disposal—1961," describes some of the work being done on the problem.
[57] Available from Office of Technical Services, Department of Commerce, Washington, D.C., price $1.75.

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the Stanford Research Institute from research on zirconium and titanium combustion. The report in part concludes:

"Whereas the mechanism of spontaneous ignition of metals with oxide free surfaces is relatively simple and its characteristics can be explained on the basis of simple kinetic considerations, the ignition mechanism of 'protected' (i.e., normal) metal surfaces is obscure, since models of diffusion controlled reactions do not agree with the experimental findings" * * * "* * * diffusion controlled reactions should be relatively independent of pressure, whereas under the conditions of the experiments * * *" * * * "pressure appears to be of critical importance."

Electronic Computer Fire Protection

Questions as to the adequacy of fire protection for the highly important electronic computers used by the Commission's laboratories were raised as a consequence of a large-loss fire experienced during 1959 at the Department of Defense Pentagon headquarters. To find the answers, a Commission engineer was assigned to review computer fire protection in all the Commission facilities and to represent the Commission on the National Fire Protection Association Committee which was formed, subsequent to the Pentagon fire, to develop fire protection standards in this area. A report detailing comments and recommendations of the staff specialist is in preparation.

Liquid Hydrogen Hazard Research

Liquid hydrogen bubble chambers have come into increasing use as adjuncts to research involving particle accelerators and nuclear reactors. Information derived from bubble chamber fire and explosion hazard studies by the Lawrence Radiation Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory has recently been supplemented by research in this area now being performed under Commission contract by the U.S. Bureau of Mines office in Pittsburgh, Pa.

Continued Study of Beryllium Threshold Limits

The use of beryllium has expanded considerably in recent years so that now 18 Commission contractors are utilizing this material in some form. In view of this increased use, the Division of Operational Safety reconvened the Beryllium Medical Advisory Committee to review the threshold limits for beryllium in the light of the 12 years of experience since these limits were established. In keeping with the

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recommendation of this Committee, the Division of Operational Safety is presently seeking a qualified epidemiological group to conduct a study relating the airborne beryllium concentrations measured in beryllium refineries to the clinical experience of employees exposed to these concentrations.

RADIOLOGICAL ASSISTANCE PROGRAM

Assistance Responses

During calendar year 1961 the Commission's Operations Offices continued to respond to requests for assistance in incidents involving known or alleged radiation hazards. Table 11, below, summarizes by radiological assistance geographical region and the respective responsible Operations Offices [58] the number of requests for assistance that were received during the first 11 months of 1961. As shown, the assistance may include the services of a full radiological assistance team, or the services of one trained individual, or only the furnishing of information and advice.

TABLE 11.—SUMMARY OF AEC RADIOLOGICAL ASSISTANCE RESPONSES for Calendar Year 1961

Region No.	Operations office	Disposition of requests				Radioactivity involved	
		Total requests	Team sent	Man sent	Advice only	Yes	No
1	NY	22		6	16	8	14
2	OR	9	5	2	2	9	
3	SR	2			2	2	
4	AL	11	4	1	6	11	
5	CH	20	7		13	9	11
6	ID	3	2		1	2	1
7	SAN	67		12	55	12	55
8	HA	0	0	0	0	0	0
Grant total		134	18	21	95	53	81

Although there has been a considerable increase in atomic energy activities during the past three years there has not been any large increase in radiation incident assistance requests from industrial and Government operations. As a result, the Commission's emergency radiological monitoring team capability has not needed to be increased [59] to meet requests for assistance. A summary of the number of the Commission's responses to requests for assistance in radiological incidents from the inception of the AEC Radiological Assistance Plan in June 1958 [60] to November 30, 1961, appears below in Table 12.

[58] See p. 265, Annual Report to Congress (January–December 1960).
[59] See p. 264, Annual Report to Congress (January–December 1960).
[60] See pp. 195–96, Semiannual Report to Congress (January–June 1958).

TABLE 12.—SUMMARY OF AEC RADIOLOGICAL ASSISTANCE RESPONSES for the period July 1958 through November 1961

Region No.	Operations office	Disposition of requests				Radioactivity involved	
		Total requests	Team sent	Man sent	Advice only	Yes	No
1	NY	74	7	22	45	35	[illegible]
2	OR	18	6	4	8	12	[illegible]
3	SR	10	1	3	6	10	[illegible]
4	AL	34	10	6	18	25	----------
5	CH	40	19	4	17	25	[illegible]
6	ID	10	6	3	1	8	[illegible]
7	SAN	68	----------	12	56	12	[illegible]
8	HA	51	6	34	11	22	[illegible]
Grand total		305	55	88	162	149	[illegible]

Interagency Plan

In June 1961, the Commission approved AEC participation in the Interagency Radiological Assistance Plan (IRAP) as a participating Federal agency. The IRAP is the outgrowth of a study started in May 1958, by a committee composed of representatives from 13 Federal agencies.[61] The Federal agencies presently signatory to the IRAP are the Atomic Energy Commission; Department of Defense; Department of Commerce (U.S. Weather Bureau); Department of Health, Education, and Welfare; Department of Labor; Federal Aviation Agency; Interstate Commerce Commission; National Aeronautics and Space Administration; Office of Emergency Planning (formerly Office of Civil and Defense Mobilization); Post Office Department; and Treasury Department (U.S. Coast Guard). Under the provisions of the IRAP, the Commission is designated the Federal agency responsible for administration, implementation, application, and coordination of the provisions of the Plan with the cooperation of the other participating Federal agencies and the fulfillment of their responsibilities. No significant changes in AEC Radiological Assistance Plan operations will be required to carry out its responsibilities under the IRAP. Currently effective mutual radiological assistance activities under the Department of Defense-Atomic Energy Commission Joint Agreement of February 27, 1958, are expected to continue essentially unchanged.

[61] See pp. 268–70, Annual Report to Congress for 1959.

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The IRAP provides that the Commission will carry out its responsibility through a national coordinating office at AEC Headquarters. The functions of the regional coordinating offices at the Commission's field offices, as specified in the IRAP, will be assumed by the eight AEC Operations Offices that presently have been assigned regional areas of responsibility for radiological assistance under the AEC Plan.

INSPECTION AND APPRAISAL

The Commission's Management Appraisal program was reoriented to encourage more selective and more intensive appraisals of Commission and contractor operations by the various elements which perform such reviews. Annual appraisal plans are closely co-ordinated with line management and provision is made for refining or developing appraisal standards and criteria.

Under a recent clarification of its functions, the Commission's inspection program has increased the use of independent, test inspections as a means of checking on Commission management of its contractor-operated activities, and to review for adequacy specialized inspection, audit, and appraisal programs. A program of formal evaluation of the performance of operations offices was completed, and summary appraisals of the over-all performance of 46 major, cost-reimbursable contractors were prepared by the Commission's Operations Offices which administer them.

A special program of inspecting the Operations Offices' reactor safety procedures and practices, performed early in 1961, indicated that in some areas there was a need for improving the reactor safety programs for those facilities under field office jurisdiction. The programs designed to ensure reactor safety at each of the Commission's operations offices were reviewed in September and are being revised where necessary. Where needed procedures are being amended to adopt those recommendations appropriate to the programs under the Operations Office's jurisdiction. Follow-up examinations will be made on these programs to determine how well they are being carried out, including inspections of representative reactors from time to time to test the validity of the inspections by field offices.

Investigations were also made during the year of incidents involving such matters as health and safety (including the SL–1 reactor accident), employee conduct, and possible violations of law, both in Commission and contract operations.

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NUCLEAR MATERIALS MANAGEMENT

Review of Nuclear Materials Control System

The Commission has signed a contract with the Stanford Research Institute, Menlo Park, Calif., to study and evaluate the Commission's Nuclear Materials Management System. The objective of the contract work is to conduct a study and evaluation, primarily technical in nature, of the system's procedures for the management and control of source and special nuclear materials.

The first phase, consisting of a review of the existing system and the preparation of a plan of work, has been completed. The evaluation of the procedures and practices used by the Commission and its contractors is now underway.

Recommended Measurement Methods

The review and evaluation of measurement methods for use in atomic energy operations was continued. The Commission began gathering recommendations through a special advisory committee and through seminars during 1960. The purpose is to establish suitable methods for measuring the properties and quantities of source and special nuclear materials transferred between the Commission and private industry or foreign governments. Meetings of various seminar sections and the full seminar were held during 1961 as follows:

Plutonium Chemistry Section, April 25–26, Richland, Wash.
Mass Spectrometry Section, April 27–28, Washington, D.C.
Sampling Section, May 2–3, Washington, D.C.
Measurements Evaluation Seminar, June 6–7, Washington, D.C.

Of the approximately fifty methods that have been recommended, the major part has been given final review by the Measurements Evaluation Seminar. It is expected that review of all methods by the Commission's Advisory Committee for Standard Reference Materials and Methods of Measurement and publication of the methods will be completed early in 1962.

Standard Reference Materials

The Commission-National Bureau of Standards cooperative program, which has provided 15 uranium isotopic standards, was continued. Final values for the 15 standards were established and final certification by the National Bureau of Standards is expected early in

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1962. Investigations for preparation and certification of a uranium 236 isotopic standard and of isotopic plutonium standards were continued.

Samples of high purity plutonium metal have been prepared and analyzed by the Los Alamos Scientific Laboratory and have been transferred to the National Bureau of Standards for certification as a plutonium chemical standard.

Nondestructive Analysis of Reactor Fuels

It is now possible to analyze, nondestructively, most geometries of fuel plates or pins. The program initiated last year to develop these techniques has demonstrated the feasibility of measuring the fuel content of flat plates without comparative standards. Most other geometries require comparative standards, but these may be selected from physical rejects so that the cost of the standards is negligible. In most cases a precision of 1 percent or better is attainable.

Portable gamma ray spectrometers have been developed for use by the Commission's field offices for inventory verification, for quality control in core manufacture, and for other uranium measurement problems which may arise. Two training schools were conducted by the Argonne National Laboratory to train Commission field employees in use of the instruments and in analytical techniques.

A limited amount of development continues, directed primarily toward extension of the techniques to unique geometries and toward refinement of present techniques to improve precision.

Meetings

More than 100 Commission and contractor personnel met in Denver, Colo., June 15–16, to discuss matters of mutual concern in the field of nuclear materials management. This was the seventh annual meeting of this type.

CONSTRUCTION

Construction Costs

As of December 31, 1961, the Nation's investment in atomic energy facilities was $7.7 billion before depreciation reserves.

Total plant acquisition and construction costs incurred by the Commission during fiscal year 1961 reached a 6-year high of $307 million. Although the reactor development program continues to account for

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about 40 percent of the entire construction effort, there was a sharp increase in special nuclear materials, as well as nominal increases in all research type programs. Capital equipment costs for replacement or addition of equipment to existing plant (laboratory, hospital, and other types of equipment) also reached a 6-year high of $122 million. The following table shows capital costs incurred during the past 6 years:

Fiscal Year	New plant construction	Capital equipment (not related to construction)
	In millions	
1961	$307	$122
1960	231	101
1959	212	87
1958	210	80
1957	260	57
1956	264	38

MOBILIZATION PLANNING

Operations Continuity

Active participation was continued in planning for mobilization and continuity of Government programs designed to develop a state of readiness with respect to all conditions of a national emergency, including attack on the United States. This planning was in coordination with the Office of Emergency Planning (OEP), formerly the Office of Civil and Defense Mobilization (OCDM). Commissioner Loren K. Olson served as Commission representative on the Civil and Defense Mobilization Board which advises the OEP Director. Additionally, the Commission was represented on OCDM's eight Regional Boards, and representation was provided as necessary at the OEP Main Relocation Site.

Additional emphasis was given in Commission planning to insure the post-disaster health and safety of the public, and active participation was continued in the Defense Materials and Priorities Systems under the Defense Production Act of 1950, as amended.

In the area of civil defense, the Commission's Los Alamos Office, in cooperation with the community, took the initiative under the program of the Office of Civil Defense (Department of Defense) to identify, mark, and stock existing fallout shelters for public use in an emergency. Shelter space for the entire community population of Los Alamos, N. Mex., has been identified. Arrangements were made with the Office of Civil Defense to include Los Alamos in its pilot study for this program. The community will be the only pilot-

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study area where the entire population can be housed under emergency conditions.

The Commission carried out a comprehensive program of exercises during Operation Alert 1961. This included, for the first time, a simulation of conditions of increased international tensions preceding an assumed attack on this country. Relocation centers were activated and long-standing Commission readiness plans were invoked upon declaration of several Defense Readiness Conditions, announcement of which had previously been restricted within the Department of Defense. An extensive test of the Commission's emergency communications throughout the country was a major part of this exercise.

TRANSPORTATION AND TRAFFIC MANAGEMENT

Transportation Forums

For several years the Commission has had a specific program to provide domestic carriers (primarily rail and motor) with information on the transportation characteristics of atomic energy materials and products. This was done principally through Commission-sponsored and -conducted seminars. Such a program not only facilitates the normal supply movements but also contributes to the Nation's over-all mobilization readiness planning.

More recently, increasing activity in international transport of these materials has stimulated considerable additional interest in the radiation and related aspects of such movements, particularly on the part of water and air carriers. (See shipping problem discussion in the International Activities section of this report.) In this connection, the Commission has extended its informational program in this area to the conduct of forums for the carriers and related groups. Future meetings will feature staff presentations and technical discussions related to transportation of radioactive materials and will afford an opportunity for all participants to exchange ideas based on specific handling and transport problems.

COMMUNITY ACTIVITIES

Oak Ridge and Richland

During 1961 the communities of Oak Ridge, Tenn., and Richland, Wash., operated as local self-government municipalities and received financial assistance in accordance with the provisions of Public Law 84-221, as amended. The Commission made assistance payments for

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fiscal year 1961 to the city of Oak Ridge covering municipal and school operations totaling $2.5 million. At Richland, assistance payments in the amount of $0.3 million were made to the city of Richland; $0.5 million to School District 400; and $0.1 million to the Kadlec Methodist Hospital.

In fiscal year 1962, it is estimated that assistance payments to the city of Oak Ridge will amount to $1.2 million; the reduction from fiscal year 1961 being due to the expected receipt of state and county funds for the schools. The city has initiated litigation to recover state school funds for the second half of fiscal year 1960 and fiscal year 1961. At Richland, it is estimated that city will receive $0.4 million and the school district $0.7 million from the Commission.

Oak Ridge

As of November 30, the only remaining government property offered for sale but remaining unsold were 139 Title IX residential lots. As of November 30, all sales of Oak Ridge property had returned $26,856,000 to the Government. The following is a summary of properties that have been sold:

Single and duplex houses	4,360
Apartments (4 or more family units)	257
Vacant residential lots and parcels	1,484
Commercial properties	115
Nonprofit	33

Richland

Of the total residential properties all except 15 apartments, and certain Wherry Act lots have been sold. Some 62 commercial properties remain to be sold as does one nonprofit property. The sales of these should be accelerated now that an amendment to Section 53(c) of the Atomic Energy Community Act of 1955 has been approved. This amendment reduces the waiting period of one year after the first advertisement for sale, to 90 days before property may be sold by negotiation at less than the appraisal price. Sales of property had returned $32,277,007 to the Government as of November 30. The following properties have been sold:

Single and duplex houses	4,806
Apartments (4 or more family units)	2
Residential lots	291
Commercial properties	170
Nonprofit	12

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The program for the development and sale of lots for privately owned homes continued at Barranca Mesa in Los Alamos, N. Mex. In addition to the 118 lots completed during 1960 and sold to personnel of the Los Alamos Scientific Laboratory for construction of private homes, 91 more lots are presently being developed for the same purpose.

The program for leasing unimproved real estate for commercial purposes is continuing. During the year, new construction has been completed on some private commercial buildings and operations have been started. Additional sites have been leased and private construction started.

The $1 million housing modification program authorized for 1960 has been progressing satisfactorily with present contractors nearing completion of the work. The work is 93 percent complete.

A contractor was selected for the development of the White Rock area near Los Alamos. The contract requires development of lots and construction of at least 200 homes by June 1963, for sale to Los Alamos "project-connected" personnel. If the initial development is successful, current planning contemplates the additional construction of private homes as well as a shopping center and recreational areas. This program is another step in the direction of eliminating the housing shortage at Los Alamos.

Sandia Base Housing

During the past year, the Government housing at Sandia Base, Albuquerque, N. Mex., was transferred to the Department of Defense through the General Services Administration. The buildings, constructed in the early 1950's to provide housing for Commission and contractor employees, had been declared surplus to Commission needs during 1960.

ORGANIZATION AND PERSONNEL

Highlights of the Commission's organization and personnel changes during 1961 included:

- The regulatory functions of the Commission were further separated from those functions of an operational and developmental nature.
- A major reorganization of Commission Headquarters staff, Headquarters-Operations Office relationships, and National Laboratory program direction resulted in improved staff functional alignment, a strengthening of Headquarters-Operations Office lines of communication since the Operations Offices now report directly to the General

Manager, and provided a focal point in Headquarters for direction of laboratory development plans.

- Dr. Glenn T. Seaborg, former Chancellor of the University of California at Berkeley and Associate Director of the Lawrence Radiation Laboratory, was named Chairman of the Commission, replacing Chairman John A. McCone who resigned as of January 20, 1961.
- Dr. Leland J. Haworth, formerly Director of the Brookhaven National Laboratory, Upton, Long Island, N.Y., was named a Commissioner to fill the vacancy which had been created when Commissioner John H. Williams resigned in mid-1960.

Organization Changes

Major organizational changes during the January-December, 1961, reporting period were as follows:

In order to avoid possibility of conflict between the regulatory function and the developmental, operational, and promotional functions, on March 10, 1961, the Commission acted to separate internally these functions below the Commissioner level by establishing the position of Director of Regulation to which were assigned the Division of Licensing and Regulation, the Division of Compliance, and the Office of Health and Safety. The Director of Regulation is responsible directly to the Commission for the performance of the regulatory function.

Effective April 25, 1961, the Commission approved changes in functions and delegations of Headquarters components related to carrying out licensing and other regulatory functions. By these changes, several functions which were formerly a part of the Office of Health and Safety were reestablished in the Office of Radiation Standards, which is under the Director of Regulation. These functions included the establishment of radiation safety standards, participation in activities of the Federal Radiation Council, and cooperation with States. The remaining functions of the Office of Health and Safety, including the safety research, industrial safety, and radiological assistance functions, were combined in the Office of Operational Safety, reporting to the General Manager.

Effective May 1, 1961, the licensing inspection and investigation functions and responsibilities assigned to Managers of Operations and Heads of Divisions and Offices, Headquarters, were assigned to the Division of Compliance, Headquarters. Subsequently the Commission approved the establishment of five compliance regional offices to be located at Atlanta, Ga.; Chicago, Ill.; Denver, Colo.; New York, N.Y., and San Francisco, Calif. (See Licensed Compliance Section in Part 4 of this report.)

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Effective May 8, 1961, the Commission established an Office of Industrial Participation, which reports to the Office of the General Manager. Heretofore, responsibility for industrial development had been centered in the position of Assistant Director for Commercial Activities, Division of Reactor Development.

Effective July 1, 1961, consistent with the termination of the Aircraft Nuclear Propulsion (ANP) Program, the Lockland Aircraft Reactors Operations Office was redesignated the Lockland Area Office under the Manager, Oak Ridge Operations Office, with responsibility for closing out aircraft nuclear propulsion contracts. The Hartford Area Office, formerly under the Lockland Operations Office, was transferred to the New York Operations Office and redesignated the CANEL Division of that office. The residual functions, remaining after these changes in organization, were assigned to the Fernald Area Office, which was redesignated the Cincinnati Area Office on May 1, 1961.

On August 11, 1961, a reorganization involving major changes in the alignment of functions involving AEC Headquarters, Headquarters—Operations Offices relationships, and AEC laboratory program direction was effected. The principal changes were directed towards providing the AEC Headquarters for more direct control, review, and coordination of laboratory research programs; shortening lines of communication and chain of command for a number of field offices; and relieving program divisions of much of the administrative burden involved in the direction of Operations Office activities. Specifically:

The position of Assistant General Manager for Research and Industrial Development was redesignated Assistant General Manager for Research and Development with the added responsibilities of program direction of non-weapons research and development (except on the Plowshare program) at Ames, Argonne, Brookhaven, Lawrence Radiation, Los Alamos, and Oak Ridge laboratories.

The program direction of weapons research and development at Los Alamos Scientific Laboratory and Lawrence Radiation Laboratory remains the direct responsibility of the Director of the Division of Military Application.

A new position of Assistant General Manager for Operations was established with responsibility for assisting the General Manager in the supervision of Operations Offices reporting directly to him, and for supervising the Divisions of Construction (formerly titled Construction and Supply), Labor Relations (formerly titled Industrial Relations), Operational Safety, and Contracts (formerly Office of Contract Policy).

The position of Assistant General Manager for Plans and Production was established in lieu of the Assistant General Manager for Man-

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ufacturing, with responsibility for supervising the Divisions of Production, Raw Materials, Operations Analysis and Forecasting, Plans, and Peaceful Nuclear Explosives.

The position of Assistant General Manager for Safety was abolished.

A new Division of Peaceful Nuclear Explosives, reporting to the Assistant General Manager for Plans and Production, was established with responsibility for the program direction of the Plowshare program.

All Headquarters Offices and Divisions except the Office of the General Counsel, Office of Hearing Examiners, Office of Radiation Standards, and Office of the Secretary, and a newly titled Office of the Controller, were designated "Divisions".

Managers of Operations Offices at Chicago, Hanford, Idaho, New York, Oak Ridge, and Savannah River, now report directly to the Office of the General Manager instead of through program divisions as they did formerly.

Operations Offices at Grand Junction, Schenectady, and Pittsburgh, were redesignated Offices and continue to report to the Division of Raw Materials in the case of the former and the Division of Reactor Development in the case of the latter two.

The Brookhaven Area Office was designated the Brookhaven Office, separated from the New York Operations Office, and reports directly to the Assistant General Manager for Research and Development. The Brookhaven Office is responsible for administration of the contract for the operation of the Brookhaven National Laboratory.

On October 29, 1961, the Palo Alto Area Office was established under the San Francisco Operations Office to direct all contract activities for the Proposed Linear Accelerator Project at Stanford University.

Personnel Changes

During the January–December 1961 reporting period, the following major personnel changes took place:

Chairman John A. McCone resigned effective January 20, 1961.

Dr. Glenn T. Seaborg, was appointed Chairman by the President on February 24, confirmed by the Senate, and sworn in March 1, 1961, for the unexpired term of former Chairman John A. McCone which will end June 30, 1963. (Commissioner John S. Graham was Acting Chairman between January 20, 1961 and March 1, 1961.)

Leland J. Haworth was appointed by the President on June 15, confirmed by the Senate, and sworn in June 22, 1961, for a 5-year term as Commissioner which will expire June 30, 1966.

Dr. Gerald W. Johnson was appointed by the President as Chairman of the Military Liaison Committee, effective July 15, 1961.

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Dr. Theos J. Thompson, member of the Advisory Committee on Reactor Safeguards since November 1959, was elected Chairman of the Committee, effective January 1, 1961.

Harold L. Price, formerly Director, Division of Licensing and Regulation, was appointed Director of Regulation, effective September 18, 1961.

E. J. Bloch, formerly Assistant General Manager for Manufacturing, was appointed Assistant General Manager for Operations, effective August 14, 1961.

George F. Quinn, formerly Director, Division of Production, was appointed Assistant General Manager for Plans and Production, effective August 14, 1961.

Dr. Spofford G. English, formerly Deputy Director, Division of Research, was appointed Assistant General Manager for Research and Development, effective August 14, 1961.

John A. Hall, Assistant Manager for International Activities, transferred effective December 17, 1961. He is now serving as Deputy Director General, International Atomic Energy Agency in Vienna. A. A. Wells, Director, Division of International Affairs, was appointed Acting Assistant General Manager for International Activities.

William F. Finan, Assistant General Manager for Safety, resigned effective June 29, 1961.

Morse Salisbury, Assistant to the General Manager and former Director, Division of Information Services, since 1946 retired effective June 16, 1961.

Alfonso Tammaro, Assistant General Manager for Research and Industrial Development, retired effective November 1, 1961.

William H. Slaton, formerly Deputy Assistant General Manager for Administration, was appointed Deputy Assistant General Manager for Operations, effective August 21, 1961.

Dr. Clifford K. Beck, formerly Assistant Director for Facilities Licensing, Division of Licensing and Regulation, was appointed Deputy Director of Regulation, effective September 18, 1961.

Major General A. D. Starbird, formerly Director, Division of Military Application, was reassigned effective January 25, 1961. He was succeeded by Brigadier General Austin W. Betts, formerly Director of Advanced Research Projects Agency of the Department of Defense, effective January 26, 1961.

Ernest B. Tremmel, formerly Special Assistant to Commissioner Wilson, was appointed Director, Office of Industrial Participation (now Division of Industrial Participation), effective May 8, 1961.

Dr. Forrest Western, formerly Deputy Director, Office of Health and Safety, was appointed Director, Office of Radiation Standards, effective May 8, 1961. 5007475

Dr. Nathan H. Woodruff, formerly Director, Office of Health and Safety, was appointed Director, Office of Operational Safety (now Division of Operational Safety), effective May 8, 1961.

John S. Kelly, formerly Chief, Peaceful Nuclear Explosives Branch, Division of Military Application, was appointed Director, Division of Peaceful Nuclear Explosives, effective August 14, 1961.

Robert Lowenstein, formerly Counsel for the Division of Licensing and Regulation, was appointed Director, Division of Licensing and Regulation, effective September 18, 1961.

Edward J. Bruenenkant, Jr., formerly Acting Director, Office of Technical Information (now Division of Technical Information), was appointed Director, effective April 6, 1961.

Douglas E. George, formerly Acting Director, Division of Nuclear Materials Management, was appointed Director, effective February 5, 1961.

Frank P. Baranowski, formerly Deputy Director, Division of Production, was appointed Director, effective October 30, 1961.

Hugo N. Eskildson, Jr., Associate Director for Operations, Division of Reactor Development, was appointed Manager, Idaho Operations Office, to become effective January 1, 1962.

Lawrence G. Mohr, formerly Assistant Director for Construction and Engineering, Division of Construction, Headquarters, was appointed Area Manager, Palo Alto Area Office, to direct all contract activities for the Linear Accelerator Project at Stanford University, effective October 29, 1961.

John Erlewine, formerly Special Assistant to the Assistant General Manager for Research and Industrial Development, was appointed Senior AEC Representative, Brussels, Belgium, effective August 20, 1961.

M. Carl Walske, formerly AEC Scientific Adviser to the Conference of Nuclear Weapons, was appointed AEC Scientific Representative, London, England, effective June 25, 1961.

Ira F. Zartman, formerly Chief, Reactor Physics Branch, Division of Reactor Development, was appointed AEC Scientific Representative, Tokyo, Japan, effective September 30, 1961.

Robert W. Ritzmann, formerly Senior Evaluation Engineer, Division of Reactor Development, was appointed AEC Scientific Representative, Chalk River, Ontario, Canada, effective September 3, 1961.

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Part Four

Regulatory Activities

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ORGANIZATION

Among its various responsibilities, the Commission is charged under the law with establishing by regulation or order, such standards and instructions to govern the possession and use of special nuclear, source, and byproduct material and the design, location, and operation of nuclear facilities as the Commission may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property and to carry out the necessary licensing and inspection programs to achieve these objectives.[1]

In March 1961, the Commission adopted organizational changes to effect a further separation of its regulatory functions from its operational and developmental functions supervised by the General Manager. As a result of the reorganization, all regulatory functions were placed under the newly established Director of Regulation who reports directly to the Commission, rather than through the General Manager.

The new organizational arrangement is the third of a series of changes since the present regulatory program was established as a result of the enactment of the Atomic Energy Act of 1954. These changes have reflected the growth and development of the regulatory program as well as the Commission's purpose to separate its regulatory from its operational and developmental functions at the staff level. The first change was made in 1957 when the Commission abolished the Division of Civilian Application, which had responsibility, in addition to regulatory functions, for administering programs to encourage and stimulate private participation in the development of the peaceful uses of atomic energy. In its place, there was established a Division of Licensing and Regulation with exclusively regulatory functions. The promotional functions were assigned to other divisions of the Commission.

In late 1959, the Commission established the position of Assistant General Manager for Regulation and Safety with responsibility for the Division of Licensing and Regulation and two newly established units, the Division of Compliance and the Office of Health and Safety. All of the Commission's regulatory functions were thereby placed under the direction of an Assistant General Manager. Under this arrangement the Division of Compliance was assigned responsibility, previously administered by the Division of Inspection, for compliance

[1] Section 161 b and i, Atomic Energy Act of 1954, as amended.

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inspection of licensees.[2] The Office of Health and Safety was assigned responsibility for providing staff assistance on health and safety matters for both regulatory and contract activities, and for implementation of the provisions of the 1954 Act, as amended, relating to the conduct of AEC-State relations on regulatory matters.

Following the organizational changes made in March 1961, the Office of Health and Safety was redesignated the Office of Radiation Standards and assigned responsibilities for development of basic radiation safety standards and for administration of the AEC-State relations program in the field of licensing and regulation. All other functions of the former Office of Health and Safety were combined in the new Office of Operational Safety which reports to the Commission's General Manager.

Also, as a result of the March 1961 reorganization, field personnel concerned with the inspection of licensees were transferred to the direct authority of the Director, Division of Compliance. The field inspectors previously have reported to the managers of the Commission's operations offices.

LICENSING ACTIVITIES

Facility Licensing

During 1961, permits were issued authorizing the construction of one power reactor, five research reactors, and one production facility for the chemical processing of irradiated americium containing plutonium. One power reactor and nine research reactors were licensed to operate. Licenses were also issued authorizing the export of a power reactor to Italy, a test reactor to South Africa, and two research reactors—one to Finland and one to Japan. Applications were filed for authorizations to construct and operate one power reactor, one test reactor, seven research reactors, one critical experiment facility and one production facility. In addition, a number of amendments to existing licenses for power, test, and research reactors were issued.

Licensing actions since 1954 brought the total number of facilities licensed to operate, as of December 31, to 4 power reactors, 3 test reactors, 54 research reactors, and 15 critical experiment facilities. In addition, permits were in effect for the construction of 7 power

[2] The Division of Inspection, which remained under the General Manager continues to exercise its statutory responsibilities under Section 25 of the Atomic Energy Act of 1954, as amended, to gather "information to show whether or not the contractors, licensees, and officers and employees of the Commission are complying with the provisions of this Act * * * and the appropriate rules and regulations of the Commission."

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[3] See section on Ci
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reactors, 24 research reactors, 1 critical experiment facility, and 1 production facility.

As reported last year, *Commonwealth Edison Co.* was issued a 40-year license on October 14, 1960, authorizing operation of the Dresden reactor at Morris, Ill., at a steady-state thermal power level of 630 megawatts following a public hearing and the Hearing Examiner's Third Supplemental Intermediate Decision dated October 11, 1960. Successive extensions of the period for review of this decision were ordered by the Commission when Commonwealth shut down the reactor because of control rod difficulties.[3] When reporting the matter to the Commission, Commonwealth advised that the reactor would remain shut down until the difficulties were resolved. On February 28, 1961, the Commission remanded the proceeding to the Examiner for further hearing to consider authorization to resume operation of the Dresden reactor with modified control rod drive mechanisms, new poison blades, and revised technical specifications. By the Examiner's Order dated March 31, Commonwealth was authorized to operate the Dresden reactor at thermal power levels up to 100 kilowatts for the conduct of criticality tests. Following a further hearing on the results of these tests, the Examiner, on May 27, issued a Fourth Supplemental Intermediate Decision which granted Commonwealth authorization to resume power operations at levels up to 630 thermal megawatts in accordance with stated specifications. A license amendment setting forth the revised technical specifications was issued June 9, 1961.

Following a hearing in May, and pursuant to the Examiner's Intermediate Decision dated June 30, an amended construction permit was issued to *Consolidated Edison Co.* on August 4 approving the final design of the reactor at Indian Point, N.Y., subject to the condition that satisfactory evidence would be presented on the proposed use of 17–4 PH precipitation-hardened stainless steel in the control rod drive shafts.[4] A public hearing on issuance of a provisional operating license was held on December 7, 1961, and recessed to December 20, 1961, and further recessed at that time to January 3, 1962.

General Electric Co. filed an application for a license to construct and operate at power levels up to 12.5 thermal megawatts an experimental superheat nuclear reactor, designated as the Vallecitos Experimental Superheat Reactor (VESR), at General Electric's Vallecitos Atomic Laboratory in Alameda County, Calif. An informal public meeting, the first of this nature, was held on June 19 in Pleasanton, Calif., to give the public residing in the area of the proposed reactor site an opportunity to ask questions of Commission regulatory per-

[3] See section on Civilian Nuclear Power Reactor Program in Part One.
[4] The 17–4 PH stainless steel had been found to be a cause of the Dresden problems.

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sonnel and for Commission representatives, in turn, to describe the AEC regulatory procedures and review of safety considerations involved in the proposed reactor. Following a formal public hearing held June 29, and pursuant to the Hearing Examiner's Intermediate Decision dated July 25, and the Commission's Order dated August 8, a construction permit was issued August 10 authorizing the company to construct the VESR. General Electric is presently operating the Vallecitos Boiling Water Reactor (VBWR) at the same site. In February, the Commission was advised that operation of the VBWR had been suspended so that certain 17–4 PH stainless steel reactor components could be replaced, and in March the company was ordered to submit detailed information relating to replacement of the reactor components and not to resume operation of the reactor until authorized by the Commission. On April 13, General Electric was authorized to resume operation of the VBWR, and on September 21 authorization was given to perform a control rod material test in the VBWR. The test involved the fastening of pieces of a new type of control rod material to a standard control rod blade to evaluate its long-term performance in the environment of a boiling water reactor. The company was also authorized, during July, to modify the nitrogen loop of the General Electric Test Reactor (GETR) to permit operation of the loop with coolant gas mixtures. General Electric was also granted authorization for the proposed change and experiments, as described in the company's Modification Report No. 12, to be conducted in a cubicle of the GETR subject to certain Commission limitations and procedures.

Following a hearing held in December 1960, and pursuant to the Hearing Examiner's Intermediate Decision of March 3, 1961, a provisional operating license was issued the *National Aeronautics and Space Administration* (NASA) on March 14 for operation of its Plum Brook testing reactor near Sandusky, Ohio. This license was issued under provisions of the Commission's regulations which permit issuance of a license in a proceeding where construction of a facility has not been completed, but is continuing satisfactorily and there is reasonable assurance that the facility will be ready for initial loading within 90 days. Under the terms of the license, NASA was permitted to load fuel into the reactor only after the Commission staff found that certain required systems or items in the reactor had been constructed and tested and that modification of the reactor controls had been completed. Authorization to commence initial core loading in accordance with the provisions of the license was granted June 12. NASA plans to operate the reactor at thermal powers up to 100 kilowatts while completing additional items required for operation at the designed thermal power of 60 megawatts.

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An application was filed by the *National Bureau of Standards* for a license to construct and operate a 10-megawatt (thermal) heavy water moderated and cooled reactor near Gaithersburg, Md. An informal public safety meeting was held at Gaithersburg on November 15, at which the Commission staff presented information on the safety aspects of the proposed reactor. Members of the public were afforded opportunity to ask questions and obtain information of interest to them concerning the project. A public hearing to consider issuance of a construction permit was held November 28, 1961.

A public hearing was held on December 18, 1961, to consider the issuance of a permit to the *Philadelphia Electric Co.* for construction of a 40,000 kilowatt (electrical) advanced high temperature, gas-cooled demonstration power reactor at Peach Bottom, Pa. A public meeting was held at Delta, Pa., on December 8, 1961, at which the Commission staff presented information on safety aspects of the proposed reactor.

As reported last year, the decision of the U.S. Court of Appeals for the District of Columbia setting aside the Commission's grant of a provisional construction permit to *Power Reactor Development Co.* (PRDC) for the Enrico Fermi Atomic Power Plant, Lagoona Beach, Mich., was appealed to the U.S. Supreme Court. On November 14, 1960, the U.S. Supreme Court announced it would review the lower court's ruling and on April 26 and 27, 1961, the case was argued in the Supreme Court. On June 12, the Supreme Court announced its decision upholding the Commission's issuance of a provisional construction permit to PRDC. On July 14, PRDC was granted an extension to December 15, 1961, for completion of construction of the Enrico Fermi reactor. A further extension to September 1, 1962, was granted by the Commission on November 29, 1961.

Following a hearing held in September, and pursuant to the Hearing Examiner's Intermediate Decision dated October 11, 1961, a provisional operating license was issued on November 15, 1961, to *Saxton Nuclear Experimental Corp.* for operation of its pressurized water nuclear reactor at Saxton, near Altoona, Pa. Under the terms of the license Saxton is permitted to load fuel into the reactor only after certain findings by the Commission have been made relating to the completion of the reactor.

On February 24, 1961, the *Westinghouse Electric Corp.* was authorized to continue operation of the Westinghouse Testing Reactor (WTR) at Waltz Mill, Pa., in accordance with the authorization issued September 7, 1960. The WTR had been shut down during mid-1960 because of the partial destruction of a fuel element through over heating and subsequent melting. The September 7, 1960, authorization called for a modified venting system subject to specific

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power level minimum coolant flow conditions which would alleviate the over heating condition.

A license amendment was issued *Yankee Atomic Electric Co.* on January 12, 1961, specifying the procedures for making changes in the technical specifications of its power reactor facility at Rowe, Mass. During 1961, ten authorizations were granted to Yankee pursuant to this provision of its license after determinations by the Commission that the proposed changes did not present significant hazards considerations not described or implicit in its license application, as amended. Yankee's license was further amended on June 23 to extend the expiration date of the license to November 4, 1997. The amendment also increased the maximum authorized steady state power level from 392 to 485 thermal megawatts, revised the technical specifications, and included reporting requirements suitable for a permanent operating license.

Operator Licenses

In the year ending November 30, 1961, 406 reactor operators licenses including amendments, were issued. These included 235 new licenses and 171 license amendments and renewals. As of November 30 there were 686 operator licenses in effect.

Special Nuclear Material Licenses

For the year ending November 30, 1961, there were 408 licensing actions involving the possession and use of special nuclear material. These included 123 new licenses and 285 license amendments, renewals, and authorizations. As of November 30, there were 449 special nuclear material licenses in effect.

During 1961, as in three previous years, four companies continued to hold licenses to engage in the conversion of uranium hexafluoride obtained from Commission plants to forms needed for fabrication of fuel elements and for research and development. They were the Davison Chemical Co., Erwin, Tenn.; United Nuclear Corp., Chemicals Div. (formerly Mallinckrodt Chemical Works), Hematite, Mo.; Nuclear Materials and Equipment Corp., Apollo, Pa.; and Spencer Chemical Co., Kansas City, Mo.

As of November 30, there were 18 concerns licensed to fabricate fuel elements in their own facilities, for sale, for their own use, or for research purposes. This is in addition to work performed under Commission contract which does not require a license. The licensed fabricators are:

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Aerojet-General Corp., San Ramon, Calif.
The Babcock & Wilcox Co., Lynchburg, Va.
Battelle Memorial Institute, Columbus, Ohio
Carborundum Co., Niagara Falls, N.Y.
Clevite Corp., Cleveland, Ohio
Davison Chemical Co., Erwin, Tenn.
Engelhard Industries, Inc., D. E. Makepeace Div., Plainsville, Mass.
General Dynamics Corp., General Atomic Div., San Diego, Calif.
General Electric Co., Atomic Power Equipment Dept., San Jose, Calif.
Lockheed Aircraft Corp., Marietta, Ga.
Metals & Controls, Inc. (Formerly M & C Nuclear, Inc.), Attleboro, Mass.
The Martin-Marietta Corp., Middle River, Md.
National Lead Co., Albany, N.Y.
Nuclear Materials and Equipment Corp., Apollo, Pa.
Nuclear Metals, Inc., Concord, Mass.
Sylvania Electric Products, Inc. (Formerly Sylvania Corning Nuclear Corp.), Hicksville, N.Y.
United Nuclear Corp., Fuels Div. (Formerly Olin Mathieson Chemical Co.), New Haven, Conn.
Westinghouse Electric Corp., Forest Hills and Cheswick, Pa.

In December a license was issued to Combustion Engineering, Inc., Windsor, Conn., authorizing commercial fabrication of fuel elements.

The following companies continued to serve in their licensed capacities to reclaim unirradiated enriched uranium from scrap generated in fuel fabrication and fuel material preparation.

Davison Chemical Co., Erwin, Tenn.
Englehard Industries, Inc., Baker Platinum Div., Newark, N.J.
Nuclear Materials and Equipment Corp., Apollo, Pa.
Spencer Chemical Co., Kansas City, Mo.
United Nuclear Corp., Chemicals Div. (formerly Mallinckrodt Chemical Works), Hematite, Mo.

As of November 30, one company, Nuclear Materials and Equipment Corp., Apollo, Pa., was licensed for the commercial production of plutonium-beryllium neutron sources. Prior to the issuance of a license to this firm, all plutonium-beryllium neutron sources were fabricated at the Commission's Mound Laboratory, Miamisburg, Ohio.

Source Material Licenses

Licenses issued for the year ending November 30, 1961, including renewals and authorizing possession and use of source materials

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totalled 833. This figure includes 273 licenses issued to exporters. As of November 30, there were 600 source material licenses in effect, exclusive of export licenses.

Byproduct Material Licensing (Radioisotopes)

During the year ending November 30, 1,470 byproduct material licenses and 5,673 amendments and renewals of existing licenses were issued. Included in this number are 1,033 new byproduct material licensees: 367 in the field of medicine, 338 industrial firms, 251 Federal and State laboratories, and 77 in other fields. As of November 30, 6,512 organizations and individuals in the United States possessed byproduct material licenses. There was a net increase of 605 licensees during the past year, of which 27 percent were industrial users. Appendix 4 shows the number of byproduct material licensees by State and type of user. Two licenses were issued, pursuant to Section 30.24(f) of Part 30, Code of Federal Regulations, to authorize distribution of various types of gaging, ion generating and chromatography analytical devices for use under general license. As of November 30, there were 15 licenses in effect for this activity.

Waste Disposal Licensing

As of November 30, 1961, there were eight organizations licensed to conduct commercial services involving the disposal at sea of low activity, packaged radioactive waste. One license, held by Coastwise Marine Disposal Co., Long Beach, Calif.,[5] was revoked. No new organizations were licensed during 1961. The licensed firms are:

American Mail Line, Seattle, Wash.
California Salvage Co., San Pedro, Calif.
Crossroads Marine Disposal Corp., Boston, Mass.
Isotopes Specialties Co., Burbank, Calif.
New England Tank Cleaning Co., Cambridge, Mass.
Nuclear Engineering Co., Pleasanton, Calif. and Kearny, N.J.
Ocean Transport Co., San Francisco, Calif.
The Walker Trucking Co., New Britain, Conn.

With the exception of American Mail Line, these firms are also authorized to conduct commercial waste disposal services by transfer to Commission-designated sites near Oak Ridge, Tenn., and Idaho Falls, Idaho, for land burial. The following companies are authorized to conduct commercial waste disposal services by transfer for land burial only:

[5] See pp. 419–420, Annual Report to Congress (January–December 1960).

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Industrial Waste Disposal Corp., Houston, Tex.
Nuclear Chem Waste Disposal Corp., Houston, Tex.
Radiological Service Co., Long Island, N.Y.
U.S. Nuclear Corp., Burbank, Calif.
Tracerlab, Inc., Waltham, Mass.

In addition, seven organizations continue to be authorized to dispose of their own low-activity packaged radioactive waste at sea. The U.S. Naval Medical Research Laboratory, New London, Conn., no longer conducts its own waste disposal operations. The licensed organizations are:

California Research Laboratory, Richmond, Calif.
National Institutes of Health, Bethesda, Md.
Socony Mobile Oil Co., Paulsboro, N.J.
U.S. Fish & Wildlife Service, Beaufort, N.C.
U.S. Naval Radiological Defense Laboratory, San Francisco, Calif.
University of Georgia, Sapelo Island, Ga.
University of Hawaii, Honolulu, Hawaii

Advisory Committee on Reactor Safety

During 1961 the Advisory Committee on Reactor Safeguards (ACRS) held 9 meetings of the full committee and 30 subcommittee meetings. It furnished to the Commission 42 letters of advice concerning 9 privately owned, 16 Commission-owned, and 12 reactor projects owned by other agencies of the Federal Government. The Committee participated with the staff of the Commission in discussions directed toward the development of guides to be used in selection of reactor sites. In addition, the Committee recommended that certain studies be undertaken in other matters related to reactor safety. (More complete details on ACRS activities will be carried in the Commission's Annual Report on Indemnification and ACRS Operations which will be submitted on March 31, 1962.)

Four members of the ACRS completed initial four-year terms and declined reappointment. Three new members were appointed to the Committee by the Commission. They are:

Dr. John C. Geyer, Johns Hopkins University, Baltimore, Md.
Dr. David B. Hall, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. John P. Howe, Cornell University, Ithaca, N.Y.

The ACRS elected Dr. Franklin A. Gifford, Jr., to serve as its chairman, and Dr. Henry W. Newson to serve as vice-chairman during calendar year 1962.

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INDEMNIFICATION OF LICENSEES

The Commission revised its financial protection and indemnity regulations (10 CFR Part 140) to revise the financial protection formula applicable to reactors of certain power levels, and to prescribe the forms of indemnity agreements which the Commission will enter into with reactor licensees who furnish proof of financial protection in the form of liability insurance policies or in the form of self-insurance. Public comment was invited on a proposed amendment to establish the forms of indemnity agreements applicable to Federal agencies and non-profit educational institutions. Comment was also invited on a further amendment to implement Public Law 87-206, enacted by the Congress in 1961, to exclude coverage of property located at the site of, and used in, connection with licensed reactors.

The Commission also completed its consideration of the question whether to extend financial protection requirements and government indemnity to licensed reactor fuel fabricators who use substantial quantities of unirradiated enriched uranium. Based upon its review of the question and the evaluation of public comments received thereon, the Commission concluded that extension of the indemnity program to licensees using such materials is not justified at the present time. A similar study relating to licensed users of plutonium, uranium 233, and large quantities of byproduct material is still in progress.

At the end of 1961 indemnity agreements were in effect with 20 privately-owned organizations, 7 government agencies, and 33 non-profit educational institutions. These agreements covered the operation of 4 power reactors, 3 test reactors, 15 critical experiment facilities, 54 research reactors, and 4 reactors where fuel is stored pending the start-up of the reactors concerned.

REGULATIONS AND AMENDMENTS

During 1961, the Commission adopted [6] two new regulations as well as various amendments to existing regulations; in addition the Commission invited public comment on other proposed amendments to existing regulations.

[6] New regulations or amendments are published in the *Federal Register* at the time of adoption; proposed regulations and amendments are published in the *Federal Register* for public comment prior to consideration for adoption.

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New Regulations and Amendments Adopted

10 CFR Part 2—Rules of Practice

An amendment to Part 2 was adopted April 15, 1961, to provide a limited review procedure with respect to licensing and compliance proceedings arising under Part 2. Under this revised rule, an intermediate decision of the Hearing Examiner will become final unless any party, within 20 days of the decision, files a petition for review and the Commission, in its discretion, grants the petition. This new rule has expedited proceedings. The Commission continues to reserve the right to direct that a case be certified to it for final decision in the absence of a petition for review.

The second amendment to Part 2 requires that an applicant for a reactor construction permit or operating license, or authorization for a power demonstration reactor project which is subject to 10 CFR Part 115, or a waste disposal license, and amendments to any such applications, must serve a copy of the application or amendment on the chief executive of the municipality or county in which the facility is to be located or the activity conducted.

10 CFR Part 20—Standards for Protection Against Radiation

The regulation was amended to provide, in effect, that licenses would not be issued to authorize the disposal of radioactive waste material on privately owned land. Under the revised rule, the Commission will not approve any application for a license to receive licensed material from other persons for disposal on land not owned by the Federal Government or by a State Government.

The major revision to Part 20, effective January 1, 1961, which was reported in the 1960 Annual Report was further amended in regard to allowable concentration limits for certain mixtures of radionuclides when either the identity or the concentration of any radionuclide in the mixture is not known although it is known that specified radionuclides are not present in the mixture. The revision is more comprehensive and covers all mixtures of radionuclides encountered in licensed operation.

10 CFR Part 30—Licensing of Byproduct Material

An amendment to Part 30, effective January 12, 1961, exempts from Commission regulatory control the possession, distribution, and use of luminous dial watches and clocks containing specified, small quantities of hydrogen 3 (tritium) as the luminescent agent. The regu-

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lation was amended to make the Commission's requirements for the export of byproduct and source materials consistent with the regulations of the United States Department of Commerce as regards exports to Cuba. Under the amended regulation, export to Cuba of byproduct material having an atomic number from 3 to 83, contained in medicinals or pharmaceutical preparations, or in devices, applicators or appliances designed for use in medical diagnosis or therapy, is authorized under a general license. A specific license for export to Cuba is required for any other byproduct material or source material. (The appropriate section of Part 40 was also amended to reflect this change as it pertains to source material.)

A petition for rule making to amend Part 30 was received from Bernard Heinz of Scranton, Pa. The petition requested an amendment which would exempt from licensing and other regulatory controls the distribution, possession and use of automobile lock illuminators containing up to 15 millicuries of tritium. The requested exemption did not apply to the manufacturers of such lock illuminators. They would still be required to obtain a specific license to manufacture and distribute these illuminators in accordance with specifications approved in their respective licenses. The lock illuminator containing the tritium is intended to facilitate the insertion of a key into the lock at night or under poor lighting conditions. The Commission considered the petition, and after receipt and analysis of public comments, Part 30 was amended to provide for the distribution, possession and use of such illuminators without any Commission license.

10 CFR Part 31—Radiation Safety Requirements for Radiographic Operations

On February 27, 1961, Part 31 became effective as a new regulation. This Part establishes supplementary radiation safety standards for persons using sealed sources of byproduct material for radiography and is designed to lessen the need for routine incorporation into licenses of special provisions applicable to radiographic operations.

10 CFR Part 40—Licensing of Source Material

A comprehensive revision of Part 40 became effective February 13, 1961. Under the revised regulation, a general license is provided for possession of up to 15 pounds of source material at any one time by a physician, pharmacist, or research institution, or by a person receiving such material in medicines or drugs. The same 15 pound general license exception was applied to commercial and industrial

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firms or medical institutions using source material for educational, developmental, or commercial purposes. The revision also provides for a general license to receive title to source material and a general license to export quantities of up to three pounds of source material at any one time to specified destinations. Certain finished products containing uranium or thorium are also exempted from domestic licensing requirements.

On receipt of a petition from American Potash & Chemical Corp., the Commission reviewed the deletion from Part 40 of the exemption from licensing of rare earth metals and compounds, mixtures and products containing not more than 0.25 percent by weight thorium, uranium, or any combination of these two elements. The exemption was restored to Part 40 as of April 11, 1961.

A further amendment to Part 40 was made to extend the exemption previously granted for the use of uranium in aircraft counterweights installed in aircraft to include not only the counterweights, when installed, but also exempt the storage and handling of such counterweights in, or from, aircraft. The amendment also exempted from specific licensing those persons exporting uranium in the form of aircraft counterweights when installed in aircraft.

10 CFR Part 50—Licensing of Production and Utilization Facilities

Effective June 6, 1961, the definition of production facility as used in Part 50 was modified. The modification was intended to exempt the processing of slightly irradiated uranium from the licensing requirements of Part 50. Such processing would still be subject to the requirements of Part 30 and Part 70. The amendment resulted from a Commission study which concluded that irradiated materials containing very small amounts of fission products having such low levels of fission product activity that they needed no additional radiological safety precautions beyond those necessary in connection with the processing of unirradiated materials should be treated similarly.

Further amendments were made which provided procedures for the transfer of licenses, the enforcement of creditors' rights against licensed facilities, and the surrender and termination of licenses. These particular amendments also granted consent to the creation of mortgages or other liens on licensed facilities.

10 CFR Part 70—Special Nuclear Material

A new reporting requirement was added to Part 70, effective January 12, 1961. This amendment requires licensees who transfer or receive special nuclear material to submit reports to the Commission.

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10 CFR Part 115—Procedures for the Review of Certain Nuclear Reactors Exempted From Licensing Requirements

This new regulation formalized in regulatory form, the Commission's policy to provide opportunity for public participation in the consideration of safety aspects of reactor projects in the Commission's power demonstration reactor program. Nuclear power reactors under the "second round" [7] of the Commission's power reactor program are not subject to the formal licensing requirements of the Atomic Energy Act. Under Section 110 of the Act, they are exempt from licensing requirements because they are to be constructed and operated under contracts "with and for the account of" the Commission. These reactors, like all other Commission-owned reactors, are nevertheless given the same technical review as licensed reactors to assure the public health and safety.

The new Part 115 provides that the hazards reports filed by prime contractors for the construction and operation of these reactors will be made available for public inspection, as will the copies of the reports made by the Commission's Advisory Committee on Reactor Safeguards and the hazards evaluations prepared by the staff of the Division of Licensing and Regulation. These cases receive compliance-type inspections and are also set down for public hearing to consider health and safety questions involved in the proposed construction and operation. The rule provides that a construction authorization and an operating authorization corresponding to the construction permits and operating licenses issued pursuant to Part 50 will be required prior to the start of construction or the start of operation. Reactor projects within this category are also made subject to the regulatory requirements of Part 20, Part 55 and certain sections of Part 2.

10 CFR Part 140—Financial Protection Requirements and Indemnity Agreements

The levels of financial protection required by this Part were reevaluated during 1960 in accordance with the Commission's announcement to that effect issued on April 7, 1960. As a result of the reevaluation the formula prescribed in section 140.12 of Part 140 for determining amounts of financial protection required for reactors of certain power levels, was revised to give greater effect to differences in locations of reactors in terms of population density.

[7] See section on Progress in Power Reactor Technology in Part 2.

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The form of the indemnity agreement which the Commission will execute with licensees who furnish liability insurance policies as proof of financial protection, and the form of indemnity agreement which the Commission will enter into with licensees furnishing proof of financial protection in the form of their own resources, were published as effective rules during 1961. Proposed forms of indemnity agreements which the Commission will execute with Federal agencies and nonprofit educational institutions were also published for public comment. The latter forms, except for changes made because Federal agencies and nonprofit educational institutions are not required to furnish financial protection, are similar to those adopted by the Commission for execution with licensees who furnish financial protection.

Proposed Regulations and Amendments

10 CFR Part 9—Public Records

A proposed amendment to Part 9 was published in the *Federal Register* on October 5, 1961, providing for inclusion in the public record of reports of incidents filed by licensees pursuant to the requirements of licenses and regulations. The amendment would exclude from the public records the names of individuals who have been exposed to radiation. In order to implement this, the reporting requirement of Part 20 will be amended to require licensees to report separately to the Commission the names of individuals who have been exposed to radiation. The provision of the proposed amendment would also extend to holders of authorizations to construct and operate power demonstration reactors subject to Part 115. The appropriate sections of Part 20 would be similarly revised.

10 CFR Part 30—Licensing of Byproduct Material

The Commission received a petition for rule making from the Lockheed Aircraft Corp. requesting an amendment to Part 30 to exempt from licensing requirements tritium activated luminous buttons or exit markers used in aircraft. These markers may contain up to 30 millicuries of tritium. The petition was published in the *Federal Register* on September 12, 1961, and public comments solicited. The comments are being reviewed and staff analysis is underway.

Also published for public comment was a proposed amendment which would establish criteria for the issuance of specific licenses to manufacture or import automobile lock illuminators containing tritium.

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10 CFR Part 50—Licensing of Production and Utilization Facilities

A proposed amendment of this Part was published in the *Federal Register* on April 8, 1961, designed to clarify the extent to which licensees may make changes and conduct tests and experiments which are not specifically provided for in their facility licenses. The proposed amendment is a substantial revision of existing Section 50.36 "Designation of Technical Specifications" and adds, among other things, an Appendix A, "Contents of Technical Specifications". The proposed amendment is based substantially on the provisions incorporated in License No. DPR-1 pursuant to the Commission's Memorandum and Order dated November 2, 1960 in the matter of the Vallecitos Boiling Water Reactor of the General Electric Co.

A second proposed amendment of Part 50 was published October 12 which would require that a facility licensee designate individuals to be responsible for directing the licensed activities of licensed operators. The individuals so designated would be licensed as "supervisory operators" under Part 55. The proposed amendment would also require that an operator licensed under Part 55 be present at the controls at all times during the operation of the facility, and that a supervisory operator be present at the facility during the performance of all non-routine operations and be readily available on call during routine operations. Corresponding amendments have been proposed to appropriate sections of Part 115.

10 CFR Part 55—Operators' Licenses

A proposed amendment to Part 55 was published in the *Federal Register* on October 12, 1961, providing for the licensing of individuals as supervisory operators of facilities and setting forth the general qualifications and requirements for their licensing. A supervisory operator is any individual designated by a facility licensee under 10 CFR Part 50 to be responsible for directing the licensed activities of licensed operators. The proposed amendment provides for a number of other changes to Part 55 which are deemed desirable and are based on the experience acquired to date in the administration of the operator license program.

10 CFR Part 72—Regulations To Protect Against Accidental Criticality and Radiation Exposure in the Shipment of Irradiated Fuel Elements

The proposed regulation is designed to assure that appropriate precautions are taken in connection with shipments of irradiated fuel

elements to protect against accidental criticality, radiation exposure to individuals, and release of fission products. This proposed regulation would govern persons subject to licensing under Part 70 of the Commission's regulations.

10 CFR Part 100—Reactor Site Criteria

The proposed rule describes criteria which will guide the Commission in its evaluation of the suitability of proposed sites for power and test reactors subject to Part 50. Recognizing that insufficient experience has been accumulated to permit the writing of detailed standards that would provide a quantitative correlation of all the factors significant to the question of acceptability of reactor sites, this rule is intended primarily to identify a number of factors considered, and the general criteria utilized by the Commission as guides in approving or disapproving proposed sites.

10 CFR Part 140—Financial Protection Requirements and Indemnity Agreements

The Commission issued a notice that it was proposing to amend all of the forms of facility indemnity agreements as they pertain to the definition of public liability. Public Law 87–206 passed in 1961 changed the definition of public liability as defined in the Atomic Energy Act of 1954, as amended, to exclude coverage of property at the site of, and used in connection with, the licensed activity.

10 CFR Part 150—Exemptions and Continued Regulatory Authority in Agreement States Under Section 274

The proposed rule is designed to provide for a discontinuance by the Commission and a corresponding assumption by the agreement States of regulatory authority and responsibility within the confines of the licensing agreement States with respect to certain activities involving byproduct material, source material, and special nuclear material in quantities less than a critical mass.

Excluded from such agreements for discontinuance of Commission authority under the proposed rule as directed by Section 274 of the Act, is regulatory authority and responsibility with respect to: the construction and operation of any production and utilization facility; the export from or import into the United States of any byproduct, source, or special nuclear materials or of any production or utilization facility; and the disposal into the ocean or sea of byproduct, source, or special nuclear waste materials.

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The Commission has not indicated its position with respect to two optional reserve areas provided by Section 274; namely, the disposal of such byproduct, source or special nuclear materials as the Commission determines by regulation or order should, because of the hazards or potential hazards, be licensed by the Commission; and the transfer of possession or control of products containing source, byproduct or special nuclear materials.

In the proposed rule, the Commission invites public comment on the alternatives available to it with respect to these two areas of regulatory authority.

Draft Technical Standards for Transport of Radioactive Materials

During December 1961, the Commission published in the *Federal Register*, for public comment, a set of draft technical standards for the shipment of radioactive materials. The draft standards were developed as a result of the work of an interagency committee composed of representatives of the Interstate Commerce Commission, the Federal Aviation Agency, U.S. Coast Guard, the Post Office Department, the Atomic Energy Commission, and the Bureau of Explosives of the Association of American Railroads. The proposed standards cover all types of shipments of radioactive materials. Further evaluation of the standards will be made in the light of public comments received in response to the Commission's invitation.

SUMMARY OF FORMAL HEARINGS

During 1961, the Commission held formal public hearings in the proceedings described below:

Coastwise Marine Disposal Co., Long Beach, Calif.

Last year's Annual Report covered the hearings relative to revoking the waste disposal license of Robert Boswell, doing business as Coastwise Marine Disposal Co.[8] By Memorandum and Order of January 27, 1961, the Commission found Coastwise responsible for numerous violations of the Atomic Energy Act, the regulations, and the terms of its license, and ordered Coastwise's license revoked.

Commonwealth Edison Co., Dresden, Ill.

By a Third Supplemental Intermediate Decision dated October 11, 1960, the Hearing Examiner granted an operating license (DPR-2) to Commonwealth Edison for a full term of 40 years and

[8] See pp. 419–420, Annual Report to Congress (January–December 1960).

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consented, pursuant to Section 184 of the Act, to a mortgage being placed on the facility. The decision authorized operation at power levels up to 630 Megawatts, thermal (Mwt), and was effective immediately subject to (*1*) exceptions filed by November 1, 1960, or (*2*) review by the Commission on its own motion by November 25, 1960.

By Order of November 23, 1960, the Commission granted an AEC staff motion to extend the period for review until December 16, 1960, in order to permit investigation of difficulties encountered with the Licensee's control rod drive mechanism which had caused the reactor to be shut down on November 15. On December 7, 1960, the AEC staff submitted a motion to extend the period for Commission review until January 31, 1961, stating that the Licensee had reported that all control rod mechanisms were to be reexamined and that such examination would extend beyond December 16, 1960. The Commission granted the motion on December 14, 1960, and by an Order dated January 27, 1961, granted a subsequent AEC staff motion dated January 6, 1961, requesting further extension of the time for Commission review to March 1, 1961. This action was taken to allow the Licensee time to complete examination of the reactor control rod drive mechanisms.

By an Order dated February 28, 1961, the Commission granted an AEC staff motion dated February 24, 1961, requesting that the proceeding be remanded to the Hearing Examiner until completion of proceedings and entry of an intermediate decision upon a Notice of Hearing issued by the Director, Division of Licensing and Regulation on February 24, 1961. The Notice of Hearing specified three issues: (*1*) whether and under what conditions the Commission should authorize Commonwealth to resume operation with modified drive mechanisms; (*2*) whether certain changes in the technical specifications proposed by Commonwealth should be approved; and (*3*) whether the findings and conclusions of the Third Supplemental Intermediate Decision should be modified or supplemented on the basis of evidence to be adduced at the hearing. The Commission specifically retained jurisdiction of the proceeding and extended the period for review of the Third Supplemental Intermediate Decision until 45 days after the issuance of such further intermediate decision as might be issued pursuant to the Notice of Hearing.

By Order of March 15, 1961, the Hearing Examiner enlarged the issues to include consideration of an application amendment of February 20, 1961, proposing the substitution of poison (control) blades of a new design.

Hearings were held March 28 and 29, 1961, and on March 31, 1961, the Hearing Examiner issued an Order for Interim and Limited

Operations authorizing, effective immediately, operations up to 100 thermal kilowatts. By Order of April 21, 1961, the Hearing Examiner approved a stipulated amendment to the March 31, 1961, Order for Interim and Limited Operations regarding neutron multiplication measurements. On May 6, 1961, Commonwealth submitted a "Proposed Fourth Intermediate Decision" which would grant Licensee authority to resume power operations up to 630 Mwt, subject to exceptions and Commission review.

On May 27, the Hearing Examiner issued a Fourth Supplemental Intermediate Decision which: (*1*) granted Commonwealth authority to resume power operations at levels up to 630 Mwt, and (*2*) directed Commonwealth to perform inspections of control rod drive mechanisms, new poison blades, and the core grid structure in accordance with stated specifications. No petition for review was filed, and the Third and Fourth Supplemental Intermediate Decisions became final on July 11, 1961.

Consumers Power Co., Big Rock Point, Mich.

The 1960 Annual Report covered the hearings on Consumer's application for a construction permit to build a 75,000 electrical kilowatt (ekw), high power density, boiling water reactor.[9] The construction permit was issued on May 31, 1960, and on October 17, 1960, Consumers filed an application for amendment to their permit.

A hearing was convened on December 14, 1960, regarding the amendment application which requests the addition of technical specifications for reactor containment as well as requesting certain findings with respect to other features of the reactor. The Hearing Examiner granted Consumers' request that the hearing be continued without date pending analysis of the control rod failure at the Dresden reactor before presenting evidence directed to whether there is sufficient information to provide reasonable assurance that the general design for the control rod mechanism is adequate. (Consumers has proposed a control rod system based upon the Dresden design.)

On December 6, 1961, the applicant filed a motion for the dismissal of the hearing to consider the amendment to the construction permit on the grounds that the questions presented by the amendment could be expeditiously handled in the hearing on the application for a provisional operating license to be held. On December 21, 1961, the Commission staff filed its consent to this motion. By an order dated December 22, 1961, the Hearing Examiner dismissed the proceeding with respect to the amendment to the construction permit.

[9] See page 421, Annual Report to Congress (January–December 1960).

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Consolidated Edison Co., Indian Point, N.Y.

On April 5, 1961, the Acting Director, Division of Licensing and Regulation, issued a Notice of Hearing on Request for Amendment to Construction Permit No. CPPR–1. Hearings were held May 9 and May 12, 1961, and terminated on the latter date.

By Intermediate Decision of June 30, the Hearing Examiner granted Consolidated Edison's request for amendment of its construction permit (CPPR–1) and approving the final design of its nuclear facility now nearing completion of construction.

In the absence of petitions for review and no Commission order for review, the Intermediate Decision became final on July 31, 1961. A public hearing was held December 7, 1961, to consider issuance of a provisional operating license to Consolidated Edison Co. The hearing was recessed until December 20, 1961, and was further recessed at that time to January 3, 1962.

Consumers Public Power District (Hallam), Hallam, Nebraska

A public hearing was held November 30, 1961, to consider issuance of a provisional facility operating authorization to permit the performance of certain dry critical experiments in the Hallam Nuclear Power Facility. The Hearing Examiner, in his decision of December 28, 1961, ordered the issuance of the authorization, subject to review by the Commission either upon petition for *certiorari* or upon its own motion.

General Electric Co., Pleasanton, Calif.

By an Order of May 24, 1961, the Acting Director, Division of Licensing and Regulation, scheduled a hearing for June 29, 1961, upon General Electric's application for a construction permit for its Vallecitos experimental steam superheat nuclear reactor. By Order of June 27, 1961, the Hearing Examiner granted a Petition to Intervene filed by the State of California, to which General Electric and the AEC staff had made no objection. A hearing was held on June 29. On July 25, 1961, the Hearing Examiner issued an Intermediate Decision which ordered that, subject to review by the Commission upon its own motion or upon the granting of a petition for review, a provisional construction permit in the form attached thereto be issued. In the absence of Commission review on its own motion, or the granting of a petition for review, this decision became final on August 25, 1961.

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On July 26, 1961, General Electric filed a "Motion to Waive Waiting Period Following Intermediate Decision" which moved that: (*1*) the period for filing petitions for review be waived by the parties; (*2*) the period for Commission review of the intermediate decision be waived by the Commission; (*3*) the intermediate decision immediately become the final action of the Commission; and (*4*) a construction permit in the form recommended by the Chief Hearing Examiner be issued immediately. General Electric stated in the motion that it waived its right to file a petition for review. The Office of Atomic Energy Development and Radiation Protection of the State of California consented to the motion and waived its right to file a petition for review. The AEC's staff answer of July 28, 1961, did not object to the motion, but suggested an alternative procedure which would allow the intermediate decision to become immediately effective, but preserve the period for Commission review prior to that decision becoming the final action of the Commission. By an Order dated August 8, 1961, the Commission ordered that the intermediate decision become immediately effective. The Order provided that the Commission could, on its own motion, direct that the record be certified to it for final decision on or before August 24, 1961. In the absence of any further Commission order, the Intermediate Decision became the final decision of the Commission on August 25, 1961.

Industrial Waste Disposal Corp., Houston, Texas

In a proceeding entitled *Harris County, Texas* v. *United States of America and the Atomic Energy Commission*, a petition for review of a determination of the Commission granting a license to Industrial Waste Disposal Corp. had been filed by Harris County in the United States Court of Appeals for the Fifth Circuit. The appeal challenged the statutory authority of the Commission to issue a license authorizing the receipt, packaging, storage, and disposal in the Gulf of Mexico of low-level radioactive waste. On June 30, 1961, the Court of Appeals sustained the Commission's statutory authority and its findings in the case. The proceeding before the Commission remains open for the purpose of taking evidence concerning the integrity of low-level waste containers after disposal in the Gulf of Mexico.

Mines Development, Inc., Edgemont, S. Dak.

The 1960 Annual Report [10] covered the hearings on this firm's alleged failure to make surveys to determine airborne radioactivity and external radiation levels.

[10] See pp. 423–424, Annual Report to Congress (January–December 1960).

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By an Intermediate Decision of November 25, 1960, the Hearing Examiner found that the firm's surveys of airborne concentrations within its milling facilities were inadequate from an employee health and safety standpoint. The decision noted that, while recent surveys (made after the firm was cited) of external radiation levels were adequate, continued surveys should be required. The Hearing Examiner ordered that within 30 days Mines Development, Inc., submit a complete description of its program for such surveys, and that within 60 days, and monthly thereafter, Mines Development submit a report to the Commission of data developed under such a program.

By a Memorandum and Order of February 8, 1961, the Commission denied the exceptions taken by Mines Development to the Intermediate Decision, and ordered that the company establish programs for continual surveys of both airborne concentrations of radioactivity and external radiation levels, and submit monthly reports thereon to the Director, Division of Licensing and Regulation.

NS *Savannah* [11]

Public hearings were held March 6–8, 1961, prior to the loading of the nuclear fuel in the NS *Savannah*. By order of April 4, 1961, the Hearing Examiner granted an AEC staff motion and extended the time for filing proposed findings to April 14 and the time for filing comments to April 21, 1961.

On June 9, 1961 the Hearing Examiner issued a Recommended Report, concluding that there is reasonable assurance that the *Savannah* may be safely operated for initial sea trials, and recommending that the Commission issue authority for such operations. The recommendation was subject to the following conditions: (*1*) that complete and detailed operating procedures for Phases *III* to *V* be presented to the Commission for safety review and approval (Phase III is the installation of fuel and operations at low power; Phase *IV* is progression from zero power tests to higher power operation; and Phase *V* is initial sea trials) and that for Phase *VI* (extended sea trials), complete and detailed operating procedures be presented to the Commission for opportunity to be presented before public hearing; (*2*) that the laboratory selected to test and analyze the 17–4 PH (H900) stainless steel ma-

[11] Construction and operation of the NS *Savannah* is exempt from the licensing requirements and procedures of the Atomic Energy Act of 1954, as amended, since it is performed under contract with the Commission. However, the Commission desired that, prior to initial loading of nuclear fuel in the ship's reactor, a public hearing be held to permit public participation in the Commission's revew of nuclear safety aspects of the vessel's construction, test, and demonstration program and to place on the public record all facts relative to the nuclear safety during start-up, testing, and sea trials of the ship. Accordingly a non-adjudicatory public hearing was scheduled.

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terials be given detailed testing objectives, particularly those used in the control rods; and (*3*) that complete review, including that of the Advisory Committee on Reactor Safeguards and public hearing, be made of operating results through Phase *V* (initial sea trials) before authority is granted for Phase *VI* (extended sea trials).

By its Memorandum and Authorization dated July 24, 1961, the Commission authorized, subject to certain conditions, the loading of nuclear fuel into the NS *Savannah*, and the conduct of operations through initial sea trials (Phase *V*). On November 22, 1961, it was found that these conditions having been met, nuclear fuel would be loaded. On December 20, 1961, authorization for operation of the NS *Savannah* up to 10 percent of full power was granted and the reactor achieved criticality on December 22, 1961.

National Aeronautics and Space Administration (NASA), Sandusky, Ohio

A pre-hearing conference [12] was held on December 9, 1960, regarding the issuance of an operating license to NASA for a 60 mwt test reactor, and a hearing was held December 16, 1960.

By an Intermediate Decision dated March 3, 1961, the Hearing Examiner granted a Provisional Operating License pursuant to 10 CFR § 50.57 for operation up to 100 kilowatts, thermal. (NASA plans to operate the reactor at thermal powers up to 100 kilowatts while completing additional items required for operation at the designed thermal power of 60 megawatts.)

On March 17, 1961, the Hearing Examiner issued a Supplemental Intermediate Decision, amending the license to require that the Licensee promptly report any variance in operation conditions significantly affecting nuclear safety. No exceptions were taken to the Intermediate Decision within the prescribed period, and on March 29, 1961, the Commission agreed to permit the Intermediate Decision to become final on April 18, 1961.

National Bureau of Standards (NBS), Gaithersburg, Md.

A public hearing was held November 28, 1961, to consider issuance of a construction permit to the National Bureau of Standards for construction of a 10-megawatt (thermal) heavy water moderated and cooled nuclear reactor at a site near Gaithersburg, Md. The matter was pending with the Hearing Examiner at year's end.

[12] See pp. 423–424, Annual Report to Congress (January–December 1960).

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New York Shipbuilding Corp., Camden, N.J.

On December 29, 1960, the Director, Division of Licensing and Regulation, issued an Order to Show Cause for revocation of the firm's byproducts material license (for radiography work) and scheduled a hearing thereon. Pre-hearing conferences were held on January 24 and February 24, 1961, and the Respondent and AEC staff agreed to prepare a joint stipulation of facts and a jointly proposed order.

The Stipulation of Facts was submitted March 10, 1961, and a Proposed Memorandum Opinion and Order was submitted on March 17, 1961. At a hearing on March 24, 1961, the Hearing Examiner granted both parties until April 14, 1961, to submit briefs in support of the proposed consent order and until April 24, 1961 for replies thereto. Briefs were submitted by Respondent and the AEC staff on April 12 and 17, 1961, respectively. By letter of April 18, 1961, Respondent indicated it would submit no reply to the AEC staff brief.

By an Intermediate Decision of May 31, the Hearing Examiner ordered Respondent's license revoked for violations of the regulations and the terms of its license, and rejected a proposed consent order by Respondent and the AEC staff. On June 20, 1961, both Respondent and the AEC staff submitted petitions for review together with supporting briefs. By an Order of June 30, 1961, the Commission granted the petitions for review solely as to the following two issues: (*1*) Does Section 81 of the Atomic Energy Act of 1954, as amended, require that the Hearing Examiner without the exercise of discretion, revoke a byproduct material license for violation thereof? (*2*) In a proceeding initiated by an AEC show cause order and in the absence of intervening parties, may the (AEC) Staff and the Respondent finally dispose of such proceeding by stipulation without (*i*) the approval of the Hearing Examiner, or (*ii*) an adjudication of the issues raised by the show cause order?

In its decision dated August 8, 1961, the Commission found that: (*1*) the legislative history of Section 81 of the Atomic Energy Act, as amended, when read together with Section 186 b., establishes that the Commission is not required in every case to revoke a byproduct material license for a violation or violations thereof; (*2*) in a proceeding initiated by an AEC show cause order, the AEC staff and Respondent may not finally dispose of such proceedings by stipulation without: (*a*) approval thereof by the Hearing Examiner, according due weight to the AEC staff position and based upon a finding that the settlement is in the public interest and will provide reasonable assurance that the public health and safety will be protected; and (*b*) such adjudication of the issues raised by the show cause order as may be

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required in the public interest; (*3*) amendment of the license to provide for a one-year probationary period of operation from the date of the order is not inconsistent with the public interest and that revocation of the license is not required.

Nuclear Engineering Co., Pleasanton, Calif.

A hearing was held in San Francisco on November 16, 1960, to consider whether, in granting renewal of Nuclear Engineering's license, the Commission should prohibit the licensee from continuing the loading of packaged low level radioactive waste at Fulton's Shipyard near Antioch, Calif., and require that another site be designated in the license.

On January 25, 1961, Nuclear Engineering submitted "Proposed Amendments and Additional Findings of Fact and Conclusions of Law by Licensee." On January 26, 1961, an intervenor, the State of California, submitted proposed findings of fact together with objections to the AEC staff's proposed findings. On February 6, 1961, Nuclear Engineering submitted an answer to the State of California's objections to the AEC staff's proposed findings.

By an Intermediate Decision of March 7, 1961, the Hearing Examiner concluded that because of past operations it is reasonable to attach, as a condition to any renewal license to be issued, a requirement that the licensee shall not conduct loading operations when the City of Antioch is pumping water from the San Joaquin River (licensee's loading operations are conducted 100 yards from the intake pump used as a part-time source for the city water supply). In the absence of exceptions, the decision became final on April 11, 1961.

Philadelphia Electric Co., Peach Bottom, Pa.

A notice of hearing was issued on November 8, 1961, to consider issuance of a construction permit for construction of an advanced high-temperature gas-cooled demonstration power reactor at Peach Bottom, Pa. On November 28, the applicant filed an Answer to Notice of Hearing and Motion for Prehearing Conference. A prehearing conference was held on December 1. On December 8, the Commonwealth of Pennsylvania filed a Petition for Leave to Intervene dated December 6. The Hearing Examiner, on December 14, issued an Order Granting Intervention. A hearing was held Decem-

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[12] See p. 425,

ber 18. Proposed findings of fact are to be submitted by the applicant on January 11, and by the AEC staff on January 18, 1962.

Rural Cooperative Power Association, Elk River, Minn.

A Notice of Hearing dated November 17, 1960, scheduled a hearing for December 20, 1960, regarding issuance of an operating license for the Elk River reactor. On December 9, 1960, Applicant requested postponement of the hearing because of difficulties in the fabrication of fuel elements which prevented loading of fuel as originally scheduled. By Order of December 9, 1960, the Hearing Examiner rescheduled the hearing for March 7, 1961.

The hearing was held on March 7–9, 1961, in St. Paul, and continued without date since the fueling operation was still delayed. Subsequently small cracks were found in the weld overlay cladding of the pressure vessel further delaying the proceeding. The hearing will reconvene on at least 20 days' public notice.

Saxton Nuclear Experimental Corp., Saxton, Pa.[13]

A hearing on issuance of a provisional operating license for the reactor was held on September 6, 1961. The filing of pleadings was completed by September 27, 1961. The applicant requested that the Hearing Examiner direct that his intermediate decision be effective immediately. By Intermediate Decision dated October 11 the Hearing Examiner ordered the issuance of a provisional operating license to Saxton. This decision was effective immediately, subject to Commission review by petition or its own motion. A Provisional operating license was issued November 15, 1961.

Volk Radiochemical Co., Chicago, Ill.

On March 23, 1961, the Acting Director, Division of Licensing and Regulation, issued an Order for Modification of License charging Volk with violations in its Chicago plant of the regulations and the conditions of its license and prescribing certain modifications of the license. On April 12, 1961, the AEC staff requested an order (*1*) vacating the hearing scheduled for April 18, and (*2*) modifying Respondent's license in accordance with conditions previously specified by the AEC staff. On April 14, 1961, the Hearing Examiner issued

[13] See p. 425, Annual Report to Congress (January–December 1960).

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a Memorandum and Order which denied the motion to vacate the hearing and reserved rulings on all other questions raised by Respondent. The hearing was held on April 18, 1961, in Chicago.

On May 16, 1961, the Division of Licensing and Regulation issued an amendment to Volk's license which among other things, (*1*) directed that Volk may possess byproduct material at its Chicago facility for the purposes of storage and decontamination only, and (*2*) authorized the use of byproduct material at a new facility operated by Volk in Skokie, Ill.

Final pleadings were submitted by May 31, 1961, but by an Order of June 23, 1961, the Hearing Examiner ordered the proceeding reopened and scheduled a hearing for July 26, 1961, upon the issue of whether the proposed amendatory conditions to Volk's license considered at the April 18, 1961, hearings are applicable to operations at the new Skokie facility. The hearing was held on July 26, 1961, in Chicago. The Village of Skokie, Ill., appeared at the hearing. On October 2, 1961, the Hearing Examiner issued an Order Adding Conditions to License and Dismissing Proceedings.

Walker Trucking Co., New Britain, Conn.[14]

By an Intermediate Decision of December 30, 1960, the Hearing Examiner dismissed Walker's application for license amendment to authorize an additional storage and packaging site at New Britain, Conn. The Hearing Examiner concluded that Walker failed to submit sufficient information to show compliance with Section 20.302 of the regulations.

By a Decision dated March 23, 1961, the Commission (*1*) granted the exceptions of Walker and the AEC staff taken to the Hearing Examiner's Decision; (*2*) vacated the Intermediate Decision; and (*3*) remanded the proceeding to the Hearing Examiner for further action consistent with such decision.

By a Supplemental Intermediate Decision dated March 24, 1961, the Hearing Examiner granted the application for amendment. The City of New Britain, on behalf of itself and other intervenors, filed exceptions thereto on April 18, 1961. By a Decision of June 12, 1961, the Commission denied the exceptions and granted Walker's amendment application. On August 7, 1961, the City of New Britain, Conn., filed a petition in the Court of Appeals, District of Columbia circuit for review of the Commission's decision of June 12, 1961. As of December 31, 1961, the Court had not ruled on the petition.

[14] See pp. 425–426, Annual Report to Congress (January–December 1960).

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[15] See pp. 426–427, A
[16] See pp 421–422, A

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Yankee Atomic Electric Co., Rowe, Mass.[15]

By motion dated November 15, 1960, Yankee requested that hearings be reconvened for the purpose of amending License No. DPR–3 to conform its provisions to the views expressed by the Commission in the General Electric case [16] with respect to the scope of technical specifications and related change procedures.

By a Fourth Intermediate Decision dated December 30, 1960, the Hearing Examiner granted Yankee's motion to amend its license to eliminate the mandatory hearing requirement for all reactor changes and to authorize a new change procedure. The procedure was to be as follows: (*1*) the technical specifications are incorporated into the license and no changes may be made in the technical specifications unless authorized by the Commission; (*2*) all requests for changes must be in writing and accompanied by an appropriate hazards analysis; (*3*) if the Director, Division of Licensing and Regulation, determines that the proposed change presents "significant hazards considerations not discussed or implicit in the license applications as amended," the matter shall be referred to the Advisory Committee on Reactor Safeguards and a public hearing held; (*4*) if the Director, Division of Licensing and Regulation, determines that the proposed change does not meet the foregoing test, he may authorize the change upon finding reasonable assurance that the public health and safety will not be endangered; and (*5*) any request to operate above 392 Mwt (the limit of the present license) must be reviewed by the Advisory Committee on Reactor Safeguards and a public hearing held.

No exceptions were taken to the Fourth Intermediate Decision and, the Commission having ordered no formal review on its own motion within the prescribed time, the decision became final February 14, 1961.

By a Fifth Intermediate Decision of June 20, effective immediately, the Hearing Examiner authorized the issuance of an operating license for a period of 40 years for operations at levels up to 485 Mwt.

RADIATION INCIDENTS

Licensee Reporting

Radiation incidents occurring in the atomic energy program, both in Commission and licensee operations, are required to be reported to the Commission's headquarters. During the period July 1, 1960, through November 30, 1961, a total of 40 radiation incidents were

[15] See pp. 426–427, Annual Report to Congress (January–December 1960).
[16] See pp. 421–422, Annual Report to Congress (January–December 1960).

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reported by licensees to, and investigated by, the Commission.[17] (Incidents occurring in the Commission's contractor-operated facilities are reported under the section on Operational Safety in Part 3 of this report.) The Commission investigates all reported incidents.

For licensed operations, the criteria for incidents required to be reported are prescribed in 10 CFR Part 20.

Reporting Criteria

Under 10 CFR Part 20, immediate notification to the Commission of any incident is required which may have caused or threatened to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of one working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of $100,000.

In regard to those incidents where there can be up to 24 hours delay in reporting, 10 CFR Part 20 states:

"Each licensee shall within 24 hours notify the Manager of the appropriate Atomic Energy Commission Operations Office listed in Appendix D by telephone and telegraph of any incident involving licensed material possessed by him and which may have caused or threatened to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $1,000.

Radiation incidents reported by licensees during the period July 1, 1960, to November 30, 1961, are shown in Table 1.

[17] See pp. 277–280, Annual Report to Congress (January–December 1960) for incidents reported during period July 1, 1958–June 30, 1960.

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Date	
July 21, 1960	Mt
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Sept. 5, 1960	Co
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See footnote at

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TABLE 1.—INCIDENTS INVOLVING RADIATION REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC

(July 1, 1960–November 30, 1961) *

Date	Location	No. of persons involved	Extent of exposure	Nature of incident
July 21, 1960	Mt. Vernon, N.Y.	None		A glass ampule exploded releasing 5 to 10 curies of tritiated water. Lab was shut down immediately for 48 hours. Area was decontaminated during this 48 hour period.
July 21, 1960	Burbank, Calif.	1	Negligible	95 mc of iodine 131 were lost from a ruptured reaction vessel and subsequently released to the atmosphere. Operations were restricted thereafter to the performance of the process inside a glove box to afford better containment during such work. The use of polarized light is being investigated as a substitute procedure.
Aug. 1, 1960	Portsmouth, N.H.	1	3 rem	Employee was exposed to a 60 curie iridium 192 radiography source when it became lodged in projector tube. Licensee has consulted with manufacturer to develop ways to prevent recurrence of such incidents.
Aug. 1, 1960	San Diego, Calif.	1	3.4 rem	Received by an employee while working routinely with a 35-curie cobalt 60 source. Operating procedures have been revised.
Aug. 4, 1960	Manchester, Mass.			Loss of 7.5 mc of strontium 90 contained in a copper tube. Loss attributed to poor control and use of material. License was revoked.
Sept. 5, 1960	Compton, Calif.	1	3.375 rem	Exposure resulted from an employee following poor operating practices during radiography. Employee was removed from radiographic work and not put back on job until he was properly instructed and trained.
Sept. 30, 1960	Waltham, Mass.	None	None	30 curies of krypton 85 escaped to an unrestricted area when a seal failed in a reaction vessel. System at fault has been replaced with one having alarm and shut-off mechanism in case of malfunction.
Oct. 5, 1960	Army Chemical Center, Md.	1	3 rem	Exposure received while attempting to repair a special device containing a 330-curie cobalt 60 source. Investigation revealed exposure to be accidental. Licensee ordered to modify device to prevent recurrence of similar accident.
Oct. 18, 1960	Tulsa, Okla.	1	2.5 rem whole body, and 13 rem hand exposure	Employee received exposure while attempting to retrieve source after a piece of steel fell on the projector extension tube. Employee limited to 10% of permissible dose rate after exposure.

See footnote at end of table.

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TABLE 1.—INCIDENTS INVOLVING RADIATION REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(July 1, 1960–November 30, 1961) [a]

Date	Location	No. of persons involved	Extent of exposure	Nature of incident
Nov. 4, 1960	Burbank, Calif.	1	3 rem	Employee working in laboratory removed enclosed filters containing liquid radioactive contamination. On one occasion the filter was frozen to the container and a longer time was required to remove filter. Procedures were revised to facilitate removal without excessive exposure in similar instances.
Nov. 7, 1960	Waltham, Mass.	None	None	50 curies of hydrogen 3 escaped to an unrestricted area when a glass apparatus exploded in a chemical exhaust hood. Area was decontaminated and closed for period of one week. New plans were formulated for tritiated water production and a closer control system was instituted.
Nov. 16, 1960	Metone, Calif.	2	Each received 3.8 rem to hand	Radiography camera malfunctioned when a 37-curie cobalt 60 source failed to return to its shielded condition. The associated radiation survey instrument behaved erratically during exposure and resulted in personnel not being aware of this occurrence.
Nov. 25, 1960	Chicago, Ill.	None		Fire occurred during heat treatment of a thorium-magnesium alloy which caused damage in excess of $1,000. Closer controls were instituted and employees instructed in the proper handling of this material.
Nov. 28, 1960	Palo Alto, Calif.	None		16.9 curies of krypton 85 were lost to the atmosphere as a result of vacuum gauge control malfunctioning. A continuous operational survey of cyclic effluent discharge has been instituted. Inspection of unit by manufacturer was made and operational technique of unit clarified.
Nov. 29, 1960 to Mar. 10, 1961.	Chicago, Ill.	Undetermined.		Some employees received excessive iodine 131 deposition in the thyroid during routine laboratory work. Contamination in public areas and excessive radiation levels in unrestricted areas were noted. Company moved to new laboratory in Skokie, Ill. Contaminated areas in Chicago facility were decontaminated. Licensee is presently operating under new revised procedures in improved facilities.
Dec. 1, 1960	Camden, N.J.	2	1–25–250 rem 1–under 25 rem.	In moving radiography equipment on deck of a ship a 13-curie tritium [illegible] source fell from unlocked projector to a deck below where it remained unnoticed. Licensee modified operating procedures and is now using qualified radiography personnel.

See footnote at end of table.

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TABLE 1.—INCIDENTS INVOLVING RADIATION REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(July 1, 1960–November 30, 1961) [a]

Date	Location	No. of persons involved	Extent of exposure	Nature of incident
[illegible] 2, 1960	Washington, D.C.			A sealed source containing 0.76 grams of plutonium was lost. Investigation failed to find any reason for the loss nor was the source recovered. Steps are being taken to prevent the recurrence of similar losses.
[illegible] 8, 1960	New Brunswick, N. J.	6	30 to 90 rem—integrated dose to thyroid.	Resulted from a combination of several deficiencies in licensee's program including lack of adequate supervision, proper instructions, and adequate facilities. New procedures instituted and facilities improved.
Dec 19 to Dec. [illegible], 1960.	Burbank, Calif.	1	1.3 rem	Employee was engaged in encapsulation of 10-curie cobalt 60 sources. The cause of the one employee exposure could not be determined. Other employees engaged in similar type of work did not get excessive exposure. Employee in question was subsequently removed from this operation.
[illegible] 17, 1961	Tonawanda, N.Y.	None		2.43 curies of krypton 85 escaped to atmosphere during transfer of material to three shipping cylinders. Operator inadvertently opened the cylinder thereby permitting krypton 85 to escape into air exhaust level. Licensee installed valves which now have to be opened by special type wrenches.
[illegible] 21, 1961	Milwaukee, Wis.	1	6.5 rem	Individual entered radiation facility when a 26-curie cobalt 60 source was being exposed. No surveys were conducted prior to entering room during use of this material. Persons involved removed from radiography work.
[illegible] Quarter, [illegible]	Boston, Mass.	2	4 rem (calculated) 3 rem (calculated)	Two employees received excessive exposures to tritium in the first quarter of 1961. The cause of the exposure was unknown. Licensee investigating revised procedures and improved facilities.
[illegible] 2, 1961	Olmsted, Pa.			A leak-test device malfunctioned expelling approximately 10.5 curies of krypton 85 into a control room and then discharged to atmosphere. The unit was turned off and the area evacuated. This device to be modified to prevent a similar occurrence.
[illegible] 6, 1961	Houston, Tex.			90 millicuries of cesium 137 were released during leak testing of cesium source. Laboratory closed more than 24 hours after incident to enable licensee to decontaminate the area.
[illegible] 13, 1961	New York, N.Y.	1	2 rad beta and 6 rem gamma film badge exposure.	Exposure received during routine set-ups of patients for cobalt 60 teletherapy and X-ray treatment. Detailed circumstances of exposure could not be determined.

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[a] See footnote at end of table.

TABLE 1.—INCIDENTS INVOLVING RADIATION REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(July 1, 1960–November 30, 1961) [a]

Date	Location	No. of persons involved	Extent of exposure	Nature of incident
Feb. 20 to Mar. 4, 1961	Havertown, Pa.	1	8 rem	Dose received while performing radiography at close quarters with multicurie sources of iridium 192. Measures have been instituted requiring more careful control to assure that overexposure will not recur.
Feb. 23, 24, 1961	Minneapolis, Minn.	3	A) 7 rem to head and 50 rem to knees B) 5 rem C) 5 rem.	Individuals were engaged in installation of a 4,000-curie cobalt 60 teletherapy source. Source fell out of unit due to an access port not being closed properly and was exposed for 1 minute. Incident was result of error in judgment.
Feb. 28 to Mar. 3, 1961.	Washington, D.C.	None		A package containing about 10 millicuries of rubidium 86 was delivered to a hospital during non-working hours on Feb. 28, 1961. The next day the package could not be found. Evidence indicated that the material had been inadvertently incinerated.
April 18, 1961	El Segundo, Calif.			A 1.2 mc-strontium 90 sealed source was apparently lost or stolen from a laboratory instrument. Source could have been stolen because of a defective lock on laboratory door. Lock has since been replaced.
April 24, 1961	Houston, Tex.	3	Negligible	Accidental spill of 30 millicuries of iodine 131 due to glass test tube cracking. Incident apparently caused by structural deficiency in the glass tube. Area restricted during decontamination.
May 5, 1961	Lawndale, Calif.	5		Five employees were exposed to accidental release of 221 curies of krypton 85 into lab. room. Material found to be used by persons who were not trained as required. Corrective measures were instituted to prevent recurrence.
May 15, 1961	Mt. Vernon, N.Y.	2	Negligible	Rupture of a defective vessel containing 5 curies of hydrogen 3 caused the release of approximately 50 millicuries of hydrogen 3 to the surrounding environs. Defective vessel was replaced.
May 31, 1961	Albuquerque, N. Mex.	None		Krypton 85 gas contained in four cells was exhausted to an unoccupied, unrestricted area. Licensee has since restricted the exhaust area.
June 9, 1961	Beacon, N.Y.	None		A stop-cock in the line between the transfer manifold and vacuum manifold was left open resulting in the accidental release of 23.3 curies of hydrogen 3. A check system was instituted and the gas handling system was rebuilt.
June 16, 1961	Brooklyn, N.Y.	None		Flask containing 500 microcuries of iodine 131 was accidently broken causing contamination of a small floor area which was subsequently decontaminated.

See footnote at end of table.

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TABLE 1.—INCIDENTS INVOLVING RADIATION REPORTED BY LICENSEES AND INVESTIGATED BY THE AEC—Continued

(July 1, 1960–November 30, 1961) [a]

Date	Location	No. of persons involved	Extent of exposure	Nature of incident
July 10 to Aug. 7, 1961.	Pittsburgh, Pa.	1	16 rad beta	Person exposed was engaged in processing phosphorous 32 strontium 85 and 89. The cause of the exposure could not be determined. Individual involved was removed from isotope work.
Aug. 9, 1961	Columbus, Ohio	1	13.2 rem gamma 44.7 rem beta	During removal of an irradiated sample from a reactor, some difficulty was experienced by employee in positioning the capsule. While attempting to correct the difficulty, the irradiated sample was accidently exposed. Investigation revealed the exposure to be the result of human error.
Aug. 30, 1961	San Diego, Calif.	2	1 person received 13 rem gamma and 160 rad beta to the hands. Other person 2.6 rem gamma 32 rad beta to the hands.	Exposures occurred while unknowingly handling chlorine 38. Licensee instituted corrective action which should prevent a recurrence.
Sept. 15, 1961	Austin, Texas	None	None	A helium cell exploded damaging a tritium target which resulted in the release of approximately 10 curies of hydrogen 3 to an unrestricted area. All personnel in near proximity to the explosion were immediately evacuated and area was restricted for 24 hours after the incident. Investigation revealed that explosion was probably caused by metal fatigue of helium cell.
Oct. 30, 1961	Rock Hill, S.C.			Loss of a 0.5 millicurie-cobalt 60 OCDM sealed source. Loss was attributed to poor control and use of material. Licensee has since transferred all licensed material in his possession and is no longer engaged in an active byproduct material program.

[a] See pp. 277–280, Annual Report to Congress (January–December 1960) for incidents reported during period July 1, 1958–June 30, 1960.

LICENSEE COMPLIANCE

Under the Commission's reorganization of its regulatory functions, the Division of Compliance, which had been established during 1960, was assigned to the Director of Regulation and given the functional responsibility of conducting on-site inspections of material and facility licensees and report the status of compliance with the Commission's

rules, regulations, orders, and license provisions, and to observe and report on the safety of licensed operations. (The Division of Inspection will continue to exercise its statutory responsibilities under Section 25c of the Atomic Energy Act of 1954, as amended.[18])

Compliance Organization

Functional Centralization

Prior to the reorganization, the licensee inspection and investigation functions and responsibilities related to licensed materials were under the managers of eight of the Commission's major field Operations Offices. Compliance personnel were assigned to the Operations Offices and reported directly to the respective field managers. As a first step in realigning and centralizing the compliance function, the Commission, on May 1, 1961, transferred these responsibilities for licensee inspection and investigation to its Headquarters' staff and made these compliance personnel directly responsible to the Director.

Establishment of Inspection Regions

On September 7, 1961, the Commission approved plans for consolidation and relocation of its compliance area offices, reducing the number of area offices from eight to five regions with headquarters in Atlanta, Chicago, Denver, New York, and San Francisco. The realignment involves the location of new compliance regional offices at Atlanta to consolidate the activities formerly conducted by the Savannah River, S.C., and Oak Ridge, Tenn., Compliance Area Offices; and at Denver to consolidate the activities formerly conducted by Idaho Falls, Idaho, and Albuquerque, N. Mex., Compliance Area Offices. The location of the New York, Chicago, and San Francisco offices will be unchanged. In addition, the compliance activities conducted previously by the Hanford, Wash., Compliance Area Office will be transferred to the San Francisco Compliance regional staff.

Regions I (New York) and V (San Francisco) were established effective October 1, and the other three regions will be activated early in 1962. (See map.)

The establishment of the new regional offices will afford a better balance of workload between the offices. For example, the Hanford Compliance Area Office was responsible for only 274 material license inspections as compared to 1,280 licenses assigned to the San Francisco Compliance Office. Likewise, the establishment of fewer offices will

[18] See footnote, page 338.

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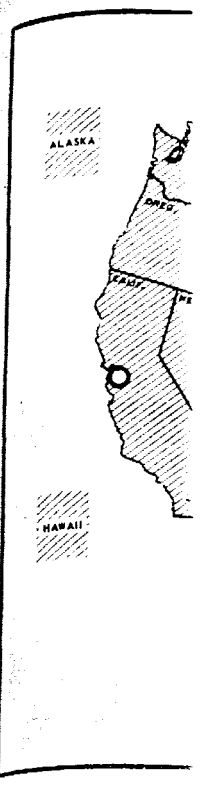

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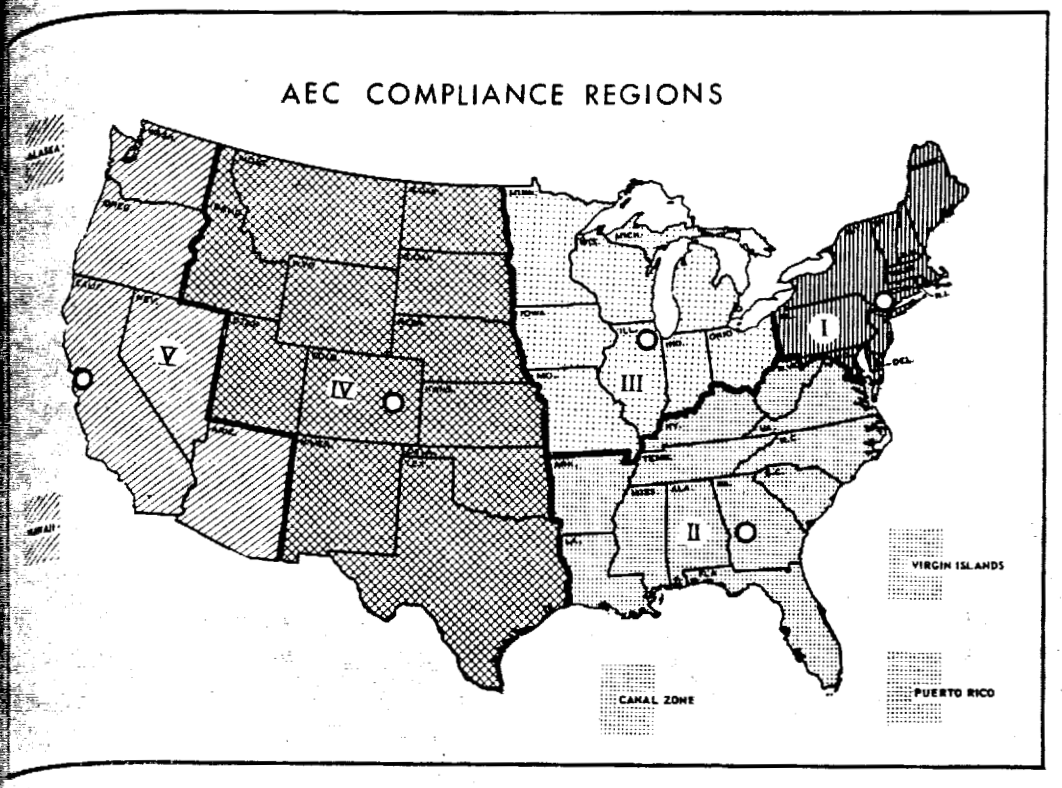

NUMBER OF ACTIVE LICENSES BY REGIONS

Region	Regional office	Materials licensees [a]	Facility licensees [b]	Milling licensees [b]
I	New York City	3,641	34	0
II	Atlanta	1,422	14	0
III	Chicago	2,381	22	0
IV	Denver	1,379	15	22
V	San Francisco	1,593	24	3

[a] Figures as of September 30, 1961.
[b] Figures as of December 31, 1961.

permit more efficient use of manpower, reduction in travel costs, and savings in travel time for personnel, since direct through-line transportation facilities are not immediately available to the Idaho, Hanford, Oak Ridge, and Savannah River Operations Offices. Under the new regional organization, nearly all licensees will be within 500 air miles of the responsible regional office. The only exception will be in the case of Texas licensees, most of whom will be over 500 air miles from the Denver office.

Licensed Facilities Inspections

Increased numbers of operating reactors and facilities under construction has led to the expansion of the staff of field inspectors from

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8 to 12 during 1961. All field inspectors have had extensive reactor operating experience, hold collegiate degrees or have equivalent experience. Approximately 200 field inspections were made and reported during the calendar year. A draft reactor inspection guide is being prepared, parts of which are currently being used.

A member of the reactor inspection staff is a member of the General Manager's Board of Investigation which was assigned to investigate the SL-1 reactor accident of last January. A member of the reactor inspection staff also gave cost-free consultation, through the International Atomic Energy Agency, to Japan; and another member of the staff took part in the development and execution of a special radiation shielding study of specific licensed reactors. A reactor inspector also served as consultant to foreign nationals and as exhibit manager during the Commission's showing of the "Atoms at Work" exhibit in Beirut, Lebanon, during October and November.

Licensed Materials

The number of active materials licenses increased 7 percent during the fiscal year, and the compliance area offices participated in a total of 2,920 inspections and 349 investigations and inquiries during the fiscal year ending June 30, 1961. Although only 7 percent of the active licenses were in the top priority group requiring the most frequent inspections, these made up 21 percent of the total inspections reported.

Aid to States

Field inspection staffs have continued to work closely with State personnel in preparation for the States to enter into agreements with the Commission to assume certain regulatory functions. Field directors and headquarters personnel were assigned to task forces to work with the Office of Radiation Standards in regard to particular States contemplating agreements.

New Notification Procedure

A change in the program for assuring compliance by materials licensees with the rules and regulations of the Commission has been made. A form-type notice is now issued to the licensee where certain, readily correctable items of noncompliance are the only items found during an inspection. The form further provides for an acknowledgment by the licensee that corrective action will be taken promptly. This new procedure reduces the number of inspection reports sub-

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[20] See pp. 266–267,
[20] See pp. 261–264,

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mitted to headquarters and eliminates correspondence with licensees on the less significant matters of noncompliance.

The delegation of this authority to appropriate field inspection personnel supplemented the authority previously given for the issuance of form notices in inspections where no item of noncompliance was found. Adoption of this method of operation allows for more effective use of technical personnel.

RADIATION STANDARDS

In order to centralize activities related to the formulation of health and safety standards, the Commission established the Office of Radiation Standards during May 1961 and placed it under the Director of Regulation.

Functional Responsibility

The Office of Radiation Standards has the assigned responsibility for coordinating all Commission efforts made in: (*a*) developing and recommending proposed health and safety standards for the protection of industrial employees and the public from atomic energy-induced radiation, and serving as a central point of Commission contact to arrange for, or to provide, technical advice and information on such standards for the use of Federal and State health and safety agencies and other Commission divisions and offices; (*b*) providing staff assistance to the Commission with respect to matters involving the Federal Radiation Council; (*c*) compiling reports from licensees and from the General Manager on all types of licensed and Commission operations which would have a bearing on health and safety standards; and (*d*) developing and administering programs in accordance with Commission policy for cooperation with qualified States to relinquish to them certain regulatory activities, including arrangements for the necessary training of State regulatory personnel.

State-AEC Relations

The Commission's program for cooperation with State and local governments to share responsibility for assuring safe atomic energy operations are carried out under Section 274 of the Atomic Energy Act, as amended in 1959.[19]

Some of the programs described previously[20] as underway were completed during 1961. These include: formulation of criteria for

[19] See pp. 266–267, Annual Report to Congress (January–December 1959).
[20] See pp. 261–264, Annual Report to Congress (January–December 1960).

determination that a State's program of radiation protection is compatible with that of the Commission; and the drafting, and distribution for comment, the suggested radiation control and licensing regulations for use by State agencies in cooperation with the Council of State governments and the U.S. Public Health Service. In addition, a proposed standard regulation concerning intra-State transportation of radioactive materials is being developed. Training programs for State and local government personnel have undergone some expansion to include extension courses and the showing of atomic energy films on educational television stations. Upon request from individual States, consultation and assistance were given on training and radiological health programs and on the development of pertinent organizational legislation and regulatory capabilities. Similarly, consultation and assistance have been provided to cities and counties on special problems. In the development of its program, the Commission has continued to seek and receive comment and advice from organizations of State and local governments and of officials of State and local governments, professional organizations, industry, labor, and other public and private groups and individuals. For instance, the Advisory Committee of State Officials was particularly helpful in providing advice on the program.

Thirteen States (Arkansas, California, Florida, Idaho, Indiana, Kentucky, Maine, New Jersey, New York, Oregon, Tennessee, Texas, and Washington) have enacted enabling legislation, one of the requirements for entering into an agreement to assume regulatory authority relinquished by the Commission, and one State (Mississippi) has determined that no amendment to its statutes is required. Other States are planning such legislation for coming legislative sessions. Seventeen State officials representing such States as California, New York, New Mexico, and New Jersey, have attended one or more of the training courses provided by the Commission, and four States (Iowa, Kentucky, Mississippi, and Oregon) have sent representatives for orientation in the Commission's licensing and licensee inspection programs.

During the year, the Commonwealth of Kentucky and the State of California completed formulation of State-approved programs, and entered into negotiations for an agreement with the Commission for transfer of regulatory authority, under the provisions of Section 274. Active negotiations with the States of New York, Texas, Mississippi, and New Jersey are in progress. Exploratory discussions have been held with several other States.

Federal Radiation Council

The Federal Radiation Council which was established in 1959 and which includes full Commission representation on the policy-making

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and working staff levels, has continued its review of radiation protection standards and practices. On September 20, 1961, the President approved recommendations as published in the *Federal Register* on September 26, 1961, concerning the exposure of the general public to iodine 131, strontium 89, strontium 90, and radium 226. Simultaneously, the Federal Radiation Council released its Staff Report #2, "Background Material for the Development of Radiation Standards". Exposure of the public to other radioisotopes is not considered to involve problems which require special consideration or changes in existing health and safety standards by the Council at this time.

The staff of the Council is preparing recommendations applicable to the mining of uranium for consideration by the Council and by the President. A study of the use of radioactive materials in products manufactured for use by the general public is in progress.

The Council's annual survey of radiation protection practices by Federal agencies indicated that all Federal agencies are operating within the radiation protection guides which have been approved by the President.

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APPENDIX 1

Organization and Principal Staff of U.S. Atomic Energy Commission

Atomic Energy Commission	Glenn T. Seaborg, *Chairman* John S. Graham Loren K. Olson Robert E. Wilson Leland J. Haworth
Secretary to the Commission	W. B. McCool
Chief Hearing Examiner	Samuel W. Jensch
Controller	Don S. Burrows
General Counsel	Neil D. Naiden

OPERATING AND PROMOTIONAL FUNCTIONS

General Manager	Alvin R. Luedecke
Deputy General Manager	Robert E. Hollingsworth
Assistant General Manager	Dwight A. Ink
Assistant to the General Manager.	Bruce A. Mercer
Special Assistant (Congressional).	Richard X. Donovan
Director, Division of Public Information.	Duncan C. Clark
Assistant General Manager for Operations.	E. J. Bloch
Deputy Assistant General Manager for Operations.	William H. Slaton
Director, Division of Construction.	John A. Derry
Director, Division of Contracts	John V. Vinciguerra
Director, Division of Labor Relations.	Oscar S. Smith
Director, Division of Operational Safety.	Nathan H. Woodruff
Assistant General Manager for Research and Development.	Spofford G. English
Director, Division of Biology and Medicine.	Charles L. Dunham, M.D.

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Director, Division of Isotopes Development.	PAUL C. AEBERSOLD
Director, Division of Reactor Development.	FRANK K. PITTMAN
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 Peaceful Nuclear Explosives.	JOHN S. KELLY
Director, Division of Plans	JOHN L. MCGRUDER
Director, Division of Production	F. P. BARANOWSKI
Director, Division of Raw Materials.	JESSE C. JOHNSON
Assistant General Manager for International Activities.	ALGIE A. WELLS, *Acting*
Director, Division of International Affairs.	ALGIE A. WELLS
Director, Division of Special Projects.	EDWARD R. GARDNER
Assistant General Manager for Administration.	HARRY S. TRAYNOR
Director, Division of Classification.	C. L. MARSHALL
Director, Division of Headquarters Services.	EDWARD H. GLADE
Director, Division of Intelligence.	C. H. REICHARDT
Director, Division of Nuclear Materials Management.	DOUGLAS E. GEORGE
Director, Division of Personnel	ARTHUR L. TACKMAN
Director, Division of Security	JOHN A. WATERS, Jr.
Director, Division of Technical Information.	EDWARD J. BRUNENKANT
Director, Division of Military Application.	BRIG. GEN. AUSTIN W. BETTS
Controller, Office of the Controller	DON S. BURROWS
General Counsel, Office of the General Counsel.	NEIL D. NAIDEN
Director, Division of Industrial Participation.	ERNEST B. TREMMEL
Director, Division of Inspection	CURTIS A. NELSON

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New York (N.
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LICENSING AND REGULATORY FUNCTIONS

Director of Regulation	HAROLD L. PRICE
Deputy Director	CLIFFORD K. BECK
Director, Division of Compliance	LAWRENCE D. LOW
Director, Division of Licensing and Regulation.	ROBERT LOWENSTEIN
Director, Division of Radiation Standards.	FORREST WESTERN

MANAGERS OF FIELD OFFICES

Albuquerque (N. Mex.) Operations Office.	KENNER F. HERTFORD
Burlington (Iowa) Area	E. W. GILES
Dayton (Miamisburg, Ohio) Area.	WILLIS B. CREAMER
Kansas City (Mo.) Area	WALTER C. YOUNGS, Jr.
Los Alamos (N. Mex.) Area	JOHN J. BURKE
San Antonio (Tex.) Area	H. JACK BLACKWELL
Pinellas (Fla.) Area	HENRY A. NOWAK
Rocky Flats (Colo.) Area	SETH R. WOODRUFF, Jr.
Sandia (N. Mex.) Area	CHARLES C. CAMPBELL
South Albuquerque (N. Mex.) Area.	WALTER W. STAGG
Brookhaven (Long Island, N.Y.) Office.	E. L. VAN HORN
Chicago (Ill.) Operations Office	KENNETH A. DUNBAR
Canoga Park (Calif.) Area	JOEL V. LEVY
Grand Junction (Colo.) Office	ALLAN E. JONES
Hanford (Wash.) Operations Office	J. E. TRAVIS
Idaho (Idaho Falls) Operations Office.	HUGO N. ESKILDSON, Jr.*
New York (N.Y.) Operations Office	JOSEPH C. CLARKE
Hartford (Conn.) Area	CLIFFORD E. MCCOLLEY
Oak Ridge (Tenn.) Operations Office	S. R. SAPIRIE
Cincinnati (Ohio) Area	CLARENCE L. KARL
Lockland (Ohio) Area	JOHN L. WILSON
New Brunswick (N.J.) Area	C. J. RODDEN
Paducah (Ky.) Area	KENNEDY C. BROOKS
Portsmouth (Ohio) Area	ROBERT H. THALGOTT
Puerto Rico (Mayaguez) Area	FLOYD P. TRENT
St. Louis (Mo.) Area	FRED H. BELCHER
Pittsburgh (Pa.) Naval Reactors Office.	LAWTON D. GEIGER

*Effective January 1, 1961.

San Francisco (Calif.) Operations Office.	ELLISON C. SHUTE
Palo Alto (Calif.) Area	LAWRENCE G. MOHR
Savannah River (Aiken, S.C.) Operations Office.	ROBERT C. BLAIR
Schenectady (N.Y.) Naval Reactors Office.	STANLEY W. NITZMAN

DIRECTORS OF COMPLIANCE FIELD ORGANIZATIONS

Albuquerque Area	ROGER T. WOOLSEY, *Acting*
Chicago Area	ROY C. HAGEMAN
Idaho Area	DONALD I. WALKER
Region I (New York)	ROBERT W. KIRKMAN
Oak Ridge Area	JACK T. SUTHERLAND, *Acting*
Region V (San Francisco)	RICHARD W. SMITH
Savannah River Area	JOHN G. DAVIS, *Acting*

AEC SCIENTIFIC REPRESENTATIVES IN FOREIGN OFFICES

Brussels, Belgium	JOHN ERLEWINE (*Senior Representative*)
Brussels, Belgium	ALLAN M. LABOWITZ
Buenos Aires, Argentina	RAYMOND R. BEARD (*Acting*)
Chalk River, Ontario, Canada	ROBERT W. RITZMANN
London, England	CARL M. WALSKE
Paris, France	VACANCY
Tokyo, Japan	IRA F. ZARTMAN

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APPENDIX 2

MEMBERSHIP OF COMMITTEES

STATUTORY COMMITTEES AND BOARD

Joint Committee on Atomic Energy—Eighty-seventh Congress

This committee was established by the Atomic Energy Act of 1946, and continued under the Atomic Energy Act of 1954, to make "continuing studies of the activities of the Atomic Energy Commission and of problems relating to the development, use, and control of atomic energy." The committee is kept fully and currently informed with respect to the Commission's activities. Legislation relating primarily to the Commission or to atomic energy matters is referred to the committee. The committee's membership is composed of 9 Members of the Senate and 9 Members of the House of Representatives.

Representative CHET HOLIFIELD (California), *Chairman.*
Senator JOHN O. PASTORE (Rhode Island), *Vice Chairman.*
Senator CLINTON P. ANDERSON (New Mexico).
Senator RICHARD B. RUSSELL (Georgia).
Senator ALBERT GORE (Tennessee).
Senator HENRY M. JACKSON (Washington).
Senator BOURKE B. HICKENLOOPER (Iowa).
Senator HENRY C. DWORSHAK (Idaho).
Senator GEORGE D. AIKEN (Vermont).
Senator WALLACE F. BENNETT (Utah).
Representative MELVIN PRICE (Illinois).
Representative WAYNE N. ASPINALL (Colorado).
Representative ALBERT THOMAS (Texas).
Representative JAMES E. VAN ZANDT (Pennsylvania).
Representative CRAIG HOSMER (California).
Representative WILLIAM H. BATES (Massachusetts).
Representative JACK WESTLAND (Washington).
Representative THOMAS G. MORRIS (New Mexico).
JAMES T. RAMEY, *Executive Director.*

Military Liaison Committee

Under section 27 of the Atomic Energy Act of 1954, "there is hereby established a Military Liaison Committee consisting of—*a.* a Chairman, who shall be the head thereof and who shall be appointed by the President, by and with the advice and consent of the Senate, who shall serve at the pleasure of the President, and who shall receive compensation at the rate prescribed for an Assistant Secretary of Defense; and *b.* a representative or representatives from each of the Departments of the Army, Navy, and Air Force, in equal numbers as determined by the Secretary of Defense, to be assigned from each Department by the Secretary thereof, and who will serve without additional compensation. The Chairman of the Committee may designate one of the members of the Committee as Acting

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Chairman to act during his absence. The Commission shall advise and consult with the Department of Defense, through the Committee, on all atomic energy matters which the Department of Defense deems to relate to military applications of atomic weapons or atomic energy including the development, manufacture, use, and storage of atomic weapons, the allocation of special nuclear material for military research, and the control of information relating to the manufacture or utilization of atomic weapons; and shall keep the Department of Defense, through the Committee, fully and currently informed of all such matters before the Commission. The Department of Defense, through the Committee, shall keep the Commission fully and currently informed on all matters within the Department of Defense which the Commission deems to relate to the development or application of atomic energy. The Department of Defense, through the Committee, shall have the authority to make written recommendations to the Commission from time to time on matters relating to military applications of atomic energy as the Department of Defense may deem appropriate. If the Department of Defense at any time concludes that any request, action, proposed action, or failure to act on the part of the Commission is adverse to the responsibilities of the Department of Defense, the Secretary of Defense shall refer the matter to the President whose decision shall be final."

Hon. GERALD W. JOHNSON, *Chairman*
Maj. Gen. BRUCE K. HOLLOWAY, United States Air Force
Rear Adm. FRANK A. BRANDLEY, United States Navy
Brig. Gen. RALPH L. WASSELL, United States Air Force
Brig. Gen. DAVID C. LEWIS, United States Army
Brig. Gen. JOHN W. KEATING, United States Army
Capt. FRANK H. BRUMBY, Jr., United States Navy

General Advisory Committee

This committee was established by the Atomic Energy Act of 1946 (Sec. 2(b)), 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. Under the Atomic Energy Act, the committee shall meet at least four times in every calendar year.

Dr. KENNETH S. PITZER, *chairman;* president, Rice University, Houston, Tex.
Dr. PHILIP H. ABELSON, director, geophysical laboratory, Carnegie Institution, Washington, D.C.
Dr. MANSON BENEDICT, professor of nuclear engineering, Massachusetts Institute of Technology, Cambridge, Mass.
Dr. WILLARD F. LIBBY, department of chemistry, University of California, Los Angeles, Calif.
EGER V. MURPHREE, president, Esso Research & Engineering Co., Linden, N.J.
Dr. NORMAN F. RAMSEY, department of physics, Harvard University, Cambridge, Mass.
Dr. J. C. WARNER, president, Carnegie Institute of Technology, Pittsburgh, Pa.
Dr. EUGENE P. WIGNER, Palmer physical laboratory, Princeton University, Princeton, N.J.
Dr. JOHN H. WILLIAMS, school of physics, University of Minnesota, Minneapolis, Minn.
Dr. ROBERT A. CHARPIE, *secretary;* Union Carbide Corp., New York, N.Y.

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Patent Compensation Board

This Board was established in April 1949 pursuant to Section 11 of the Atomic Energy Act of 1946, and is the Board designated under Section 157a of the Atomic Energy Act of 1954. Section 157 provides that upon application for just compensation or awards or for the determination of a reasonable royalty fee certain proceedings shall be held before such a Board.

ROBERT C. WATSON, *chairman;* firm of Watson, Cole, Grindle & Watson, Washington, D.C.

DOUGLAS MCLEOD COOMBS, Simmonds Precision Products, Inc., Tarrytown, N.Y.

MALCOLM W. FRASER, private practice of patent law, Toledo, Ohio

HERMAN I. HERSH, firm of Ooms, McDougall, Williams & Hersh, Chicago, Ill.

LAWRENCE C. KINGSLAND, firm of Kingsland, Rogers, Ezell and Robbins, St. Louis, Mo.

GEORGE SIPKIN, private practice of patent law, Washington, D.C.

Advisory Committee on Reactor Safeguards

The committee reviews safety studies and facility license applications referred to it and makes reports thereon, advises the Commission with regard to the hazards of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards, and performs such other duties as the Commission may request. The committee's reports on applications for facility licenses become a part of the record of the application and available to the public, except for security material. Members are appointed by the Commission for a term of 4 years each, and one member is designated by the committee as its chairman. This statutory committee replaced the former Advisory Committee on Reactor Safeguards in 1957.

Dr. THEOS J. THOMPSON, *chairman;* director, MIT nuclear reactor, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. WILLIAM K. ERGEN, principal physicist, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. JOHN C. GEYER, chairman, department of sanitary engineering and water resources, The Johns Hopkins University, Baltimore, Md.

Dr. FRANKLIN A. GIFFORD, Jr., meteorologist-in-charge, Weather Bureau Office, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

Dr. DAVID B. HALL, division leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. JOHN P. HOWE, professor of engineering, Cornell University, Ithaca, N.Y.

Dr. HENRY W. NEWSON, professor of physics, Duke University, Durham, N.C.

KENNETH R. OSBORN, chief engineer, General Chemical Division, Allied Chemical Corp., New York, N.Y.

DONALD A. ROGERS, director of project analysis, central research laboratory, Allied Chemical Corp., Morristown, N.J.

Dr. LESLIE SILVERMAN, professor of engineering in environmental hygiene and director of radiological hygiene program, Harvard University, Boston, Mass.

REUEL C. STRATTON, consulting engineer, Hartford, Conn.

Dr. CHARLES R. WILLIAMS, assistant vice president, Liberty Mutual Insurance Co., Boston, Mass.

Dr. DICK DUFFEY, *technical secretary;* professor of nuclear engineering, University of Maryland, College Park, Md.

JAMES B. GRAHAM, *executive secretary;* U.S. Atomic Energy Commission, Washington, D.C.

ATOMIC ENERGY LABOR-MANAGEMENT RELATIONS PANEL

The members of this panel were selected by the President to assist in arriving at peaceful adjustments of labor-management disputes which would imperil the Government's atomic energy program when the normal processes of collective bargaining and mediation have been fully utilized without constructive results. The panel operates under procedures designed to accomplish this purpose.

CYRUS S. CHING, *chairman;* industrial relations consultant and former Director of the Federal Mediation and Conciliation Service, Washington, D.C.

REV. LEO C. BROWN, S.J., professor of economics and director of the Institute of Social Order, St. Louis University, St. Louis, Mo.

Vice Adm. O. S. COLCLOUGH, USN, Retired, dean of faculties, the George Washington University, Washington, D.C.

ROBBEN W. FLEMING, professor of law, University of Illinois, Urbana, Ill.

CHARLES O. GREGORY, professor of law, University of Virginia, Charlottesville, Va.

RUSSELL A. SMITH, professor of law and secretary of University of Michigan Law School, Ann Arbor, Mich.

ADVISORY BODIES TO THE ATOMIC ENERGY COMMISSION

Advisory Committee for Biology and Medicine

The Advisory Committee for Biology and Medicine was created in September 1947, on the recommendation of the Commission's Medical Board of Review. The committee reviews the programs in medical and biological research and health and recommends to the Commission general policies in these fields.

Dr. JOHN C. BUGHER, *chairman;* director, Puerto Rico Nuclear Center, Rio Piedras, Puerto Rico.

Dr. H. BENTLEY GLASS, professor of biology, John Hopkins University, Baltimore, Md.

Dr. FRED J. HODGES, professor and chairman of radiology, department of radiology, University of Michigan Medical Center, Ann Arbor, Mich.

Dr. JAMES G. HORSFALL, director, Connecticut Agricultural Experiment Station, New Haven, Conn.

Dr. ROBERT F. LOEB, bard professor of medicine, Columbia University, New York, N.Y.

Dr. LEONIDAS D. MARINELLI, associate director, radiological physics division, Argonne National Laboratory, Argonne, Ill.

Dr. CARL V. MOORE, professor of medicine, department of internal medicine, Washington University, Barnes & Wohl Hospital, St. Louis, Mo.

Dr. JAMES H. STERNER, medical director, Eastman Kodak Co., Rochester, N.Y.

Dr. HARLAND G. WOOD, director, biochemistry department, school of medicine, Western Reserve University, Cleveland, Ohio.

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Dr. HENRY I. KOHN, *scientific secretary;* clinical professor of experimental radiology, University of California Medical Center, San Francisco, Calif.

Historical Advisory Committee

The Historical Advisory Committee was established by the Commission in February, 1958, to advise the Commission and its historical staff on matters relating to the preparation of the history of the Atomic Energy Commission.

Dr. JAMES P. BAXTER, III, *Chairman;* president, Williams College, Williamstown, Mass.

Dr. JAMES L. CATE, department of history, University of Chicago, Chicago, Ill.

Dr. ARTHUR H. COMPTON, Washington University, St. Louis, Mo.

Dr. FRANCIS T. MILES, Brookhaven National Laboratory, Upton, N.Y.

Dr. ISADORE PERLMAN, associate director, Lawrence Radiation Laboratory, UCLA, Berkeley, Calif.

DON K. PRICE, Jr., dean, graduate school of public administration, Harvard University, Cambridge, Mass.

Dr. RICHARD G. HEWLETT, AEC representative; chief historian, U.S. Atomic Energy Commission, Washington, D.C.

Advisory Committee on Technical Information

An advisory committee to the U.S. Atomic Energy Commission was formed in 1949 for consultation on the planning and execution of the AEC's industrial information program. The name was changed during the past year from Advisory Committee on Industrial Information and the membership altered to match better the current activities of the Division of Technical Information.

STANLEY A. TUCKER, *chairman*; publications business manager, American Society of Mechanical Engineers, New York, N.Y.

HERBERT S. BAILEY, director, Princeton University Press, Princeton, N.J.

JOHN E. DOBBIN, project director, Educational Testing Service, Princeton, N.J.

BERNARD M. FRY, deputy head, office of science information service, National Science Foundation, Washington, D.C.

JAMES L. GAYLORD, senior partner of James L. Gaylord Associates, Santa Monica, Calif.

Dr. ALLEN G. GRAY, editor, "Metal Progress", American Society for Metals, Novelty, Ohio.

EUGENE J. HARDY, National Association of Manufacturers, Washington, D.C.

NORMAN H. JACOBSON, executive business editor, "Electric Light and Power", Haywood Publishing Co., Chicago, Ill.

ANDREW W. KRAMER, editor, "Atomics," The Technical Publishing Co., Barrington, Ill.

JOHN W. LANDIS, assistant manager, atomic energy division, The Babcock & Wilcox Co., Lynchburg, Va., representing American Nuclear Society, Chicago, Ill.

FREDERIC A. PAWLEY, research secretary, American Institute of Architects, Washington, D.C.

KARL T. SCHWARTZWALDER, director of research, A–C spark plug division, General Motors Corp., Flint, Mich., representing The American Ceramic Society, Inc., Columbus, Ohio.

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OLIVER H. TOWNSEND, director, Office of Atomic Development, State of New York, New York, N.Y.

JOHN W. WIGHT, vice president, McGraw-Hill Book Co., Inc., New York, N.Y.

EDWARD J. BRUNENKANT, *secretary;* director, division of technical information, U.S. Atomic Energy Commission, Washington, D.C.

Advisory Committee on Isotope and Radiation Development

This Committee was established by the Commission in July 1958 to advise on means of encouraging widescale industrial use of radioisotopes and nuclear radiation.

Dr. PAUL C. AEBERSOLD, *chairman*; director, division of isotopes development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. JAMES F. BLACK, senior research associate, products research division, Esso Research and Engineering Co., Linden, N.J.

LAUCHLIN M. CURRIE, vice president, atomic energy division, Babcock & Wilcox Co., New York, N.Y.

SAMUEL E. EATON, Arthur D. Little, Inc., Cambridge, Mass.

Dr. HENRY J. GOMBERG, director, Memorial-Phoenix Project, University of Michigan, Ann Arbor, Mich.

JOHN J. GREBE, director, nuclear and basic research, Dow Chemical Co., Midland, Mich.

Dr. MOSES A. GREENFIELD, department of radiology, University of California, Los Angeles, Calif.

Dr. THORFIN R. HOGNESS, director, Chicago midway laboratories, University of Chicago, Chicago, Ill.

JOHN L. KURANZ, vice president, Nuclear-Chicago Corp., Des Plaines, Ill.

Dr. CLARENCE E. LARSON, vice president, Union Carbide Nuclear Co., Oak Ridge, Tenn.

JOHN J. MCMAHON, manager, marketing research, American Machinery Foundry Atomics, Greenwich, Conn.

HOMER S. MYERS, executive vice president, Tracerlab, Inc., Waltham, Mass.

Dr. LEONARD REIFFEL, director of physics research, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

Dr. LAURISTON S. TAYLOR, chief, atomic and radiation physics division, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C.

OLIVER H. TOWNSEND, director, Office of Atomic Development, State of New York, New York City.

Advisory Committee on Medical Uses of Isotopes

This committee was established in 1958 and replaces the Subcommittee on Human Applications of the Advisory Committee on Isotope Distribution. The committee will advise the Commission on policies and standards for the regulation and licensing of medical uses of radioisotopes in humans.

Dr. WALLACE D. ARMSTRONG, professor, department of biochemistry, University of Minnesota Medical School, Minneapolis, Minn.

Dr. REYNOLDS F. BROWN, department of radiology, University of California Medical School, San Francisco, Calif.

Dr. DONALD S. CHILDS, Jr., section of therapeutic radiology, Mayo Clinic, Rochester, Minn.

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Dr. JOHN A. D. COOPER, assistant dean, Northwestern University Medical School, Chicago, Ill.

Dr. GEORGE V. LEROY, associate dean, Division of Biological Sciences, University of Chicago, Chicago, Ill.

Dr. EDITH H. QUIMBY, associate professor of radiology, College of Physicians and Surgeons, Columbia University, New York, N.Y.

Dr. RULON W. RAWSON, Memorial Hospital, New York, N.Y.

Plowshare Advisory Committee

The Plowshare Advisory Committee was established in September 1959. The committee's function is to advise the Commission and the General Manager on selecting and carrying out particular Plowshare Projects; developing and making available various applications of Plowshare; and determining the general orientation and policies of the Plowshare program.

Dr. SPOFFORD G. ENGLISH, *chairman;* Assistant General Manager for research and development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. PHILIP H. ABELSON, director, geophysical laboratory, Carnegie Institution, Washington, D.C.

WILLARD BASCOM, technical director, the AMSOC Committee, National Academy of Sciences, Washington, D.C.

Lt. Gen. JAMES H. DOOLITTLE, Space Technology Laboratories, Inc., Los Angeles, Calif.

Dr. LOUIS H. HEMPELMANN, school of medicine and dentistry, University of Rochester, Rochester, N.Y.

Dr. WILLARD F. LIBBY, department of chemistry, University of California, Los Angeles, Calif.

Dr. W. RANDOLPH LOVELACE, II, Lovelace Clinic, Albuquerque, N. Mex.

Dr. DONALD H. MCLAUGHLIN, president, Homestake Mining Co., San Francisco, Calif.

Dr. PHILIP C. RUTLEDGE, partner, Moran, Proctor, Mueser & Rutledge, New York, N.Y.

Dr. PAUL B. SEARS, chairman, conservation program, Yale University, New Haven, Conn.

Dr. ABEL WOLMAN, professor, sanitary engineering, The Johns Hopkins University, Baltimore, Md.

Advisory Committee on Reactor Physics

This committee is appointed to consider the status of the development of reactor physics information required for the development of reactor concepts and the design and construction of reactors. Nuclear physics data and reactor physics studies required for the design and development of reactors and reviewed and evaluated. The committee's recommendations and advice are used in planning the research and development work in the field of reactor physics.

Dr. E. RICHARD COHEN, research adviser, Atomics International, North American Aviation, Inc., Canoga Park, Calif.

DESLONDE DE BOISBLANC, director, reactor physics and engineering, Phillips Petroleum Co., Idaho Falls, Idaho.

Dr. GERHARD DESSAUER, director, physics section, E. I. du Pont de Nemours & Co., Inc., Aiken, S.C.

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Dr. MILTON EDLUND, manager, physics and mathematics department, Babcock & Wilcox Co., Lynchburg, Va.

Dr. RICHARD EHRLICH, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N.Y.

Dr. PAUL F. GAST, manager, physics and instrument research and development, General Electric Co., Richland, Wash.

Dr. GORDON HANSEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

PHILIP B. HEMMIG, division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. IRVING KAPLAN, professor of nuclear engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. HERBERT J. C. KOUTS, experimental reactor physics group leader, Brookhaven National Laboratory, Upton, Long Island, N.Y.

Dr. SIDNEY KRASIK, Astronuclear Laboratory, Westinghouse Electric Corp., Pittsburgh, Pa.

Dr. F. C. MAIENSCHEIN, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. THEODORE MERKLE, associate director, "R" division, Lawrence Radiation Laboratory, Livermore, Calif.

Dr. THOMA M. SNYDER, manager, physics—APED, Vallecitos Atomic Laboratory, General Electric Co., Pleasanton, Calif.

Dr. BERNARD I. SPINRAD, director, reactor engineering division, Argonne National Laboratory, Lemont, Ill.

Dr. JOHN J. TAYLOR, Westinghouse Electric Corp., Bettis Atomic Power Div., Pittsburgh, Pa.

Dr. PAUL F. ZWEIFEL, professor of nuclear engineering, University of Michigan, Ann Arbor, Mich.

Dr. ALVIN RAKOWSKY, secretary; division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Advisory Committee for Standard Reference Materials and Methods of Measurement

The committee was originally established by the Commission in March 1956 as the Committee for Uranium Isotopic Standards. The Commission approved its reconstitution in January 1958 under its present title to reflect the broadened scope of its activities. The committee reviews, evaluates and recommends means for providing standard reference materials (i.e., certified chemical and isotopic standards for uranium, plutonium, etc.) and approved methods of measurement for materials of special importance to atomic energy activities.

Dr. SAMUEL C. T. MCDOWELL, *chairman;* deputy director, division of nuclear materials management, U.S. Atomic Energy Commission, Washington, D.C.

RALPH J. JONES, division of nuclear materials management, U.S. Atomic Energy Commission, Washington, D.C.

Dr. CHARLES F. METZ, group leader, analytical chemistry group, chemistry and metallurgical research division, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. HORACE W. NORTON, III, professor of statistical design and analysis, University of Illinois, Urbana, Ill.

Dr. EDWIN F. OBLEMANN, professor of chemistry and chemical egineering, University of California, Berkeley, Calif.

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C. J. RODDEN, area manager, New Brunswick Area Office, U.S. Atomic Energy Commission, New Brunswick, N.J.

CHARLES M. STEVENS, Argonne National Laboratory, Lemont, Ill.

C. D. W. THORNTON, technical director, U.S. Commercial, International Telephone & Telegraph Corp., New York, N.Y.

Dr. EDWARD WICHERS, associate director, National Bureau of Standards, Department of Commerce, Washington, D.C.

Advisory Committee of State Officials

This committee was established by the Commission in September 1955 as a means of obtaining the views and advice of State regulatory agencies in connection with the Atomic Energy Commission's regulatory activities in the field of public health and safety. It was expanded in 1960 in order to draw on a broader cross section of experience in furnishing guidance in the implementation of the Commission's program with respect to State cooperation.

WILLIAM L. BATT, Jr., secretary, Department of Labor and Industry, Harrisburg, Pa.

SALVATORE A. BONTEMPO, commissioner, Department of Conservation and Economic Development, Trenton, N.J.

JOHN D. BRECKENRIDGE, attorney general of Kentucky, Frankfort, Ky.

Dr. BERNARD BUCOVE, director of health, State Department of Health, Seattle, Wash.

Dr. R. L. CLEERE, executive director, State Department of Public Health, Denver, Colo.

NORMAN A. ERBE, attorney general of Iowa, Des Moines, Iowa.

CURTIS M. EVARTS, Jr., state sanitary engineer, Oregon State Board of Health, Portland, Oreg.

CARL FRASURE, department of political science, West Virginia University, Morgantown, W. Va.

JAMES G. FROST, deputy attorney general of Maine, Augusta, Maine.

Dr. ALEXANDER GRENDON, coordinator of atomic energy development and radiation protection, State of California, Sacramento, Calif.

Dr. ALBERT E. HEUSTIS, commissioner of health, Michigan Department of Health, Lansing, Mich.

Dr. HERMAN E. HILLEBOE, commissioner of health, State Department of Health, Lansing, Mich.

C. W. KLASSEN, chief sanitary engineer, Department of Public Health, Springfield, Ill.

Dr. MORRIS KLEINFELD, director, division of industrial hygiene, Department of Labor, New York, N.Y.

W. T. LINTON, executive director, water pollution control authority, South Carolina State Board of Health, Columbia, S.C.

HENRY M. MARX, coordinator, Atomic Development Activities, Greenwich, Conn.

KARL M. MASON, director, bureau of environmental health, Pennsylvania Department of Health, Harrisburg, Pa.

Dr. JAMES E. PEAVY, commissioner of health, State Department of Health, Austin, Tex.

WILLIAM J. PIERCE, University of Michigan Law School, Ann Arbor, Mich.

B. A. POOLE, director, bureau of environmental sanitation, Indiana State Board of Health, Indianapolis, Ind.

RAYMOND I. RIGNEY, coordinator of atomic development, The Commonwealth

D. P. ROBERTS, chief industrial hygiene section, Tennessee Department of Health, Nashville, Tenn.

ROBERT H. SOLOMONS, III, executive secretary, Regional Advisory Council on Nuclear Energy, Atlanta, Ga.

OLIVER TOWNSEND, director, Office of Atomic Development, New York, N.Y.

JAMES T. VOCELLE, chairman, Industrial Commission of Florida, Tallahassee, Fla.

Committee of Senior Reviewers

The Committee of Senior Reviewers studies the major technical activities of the Atomic Energy Commission program and advises the Commission on classification and declassification matters, making recommendations with respect to the rules and guides for the control of scientific and technical information. The Committee consists of six members appointed for a term of 5 years on a rotating basis.

Dr. ALVIN C. GRAVES, *chairman;* J. division leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. JOHN P. HOWE, professor of engineering, Cornell University, Ithaca, N.Y.

Dr. FRANK C. HOYT, Missiles System Division, Lockheed Aircraft Corp., Palo Alto, Calif.

Dr. WARREN C. JOHNSON, vice president, University of Chicago, Chicago, Ill.

Dr. WINSTON M. MANNING, director, chemistry division, Argonne National Laboratory, Lemont, Ill.

Dr. J. REGINALD RICHARDSON, professor of physics, University of California at Los Angeles, Calif.

Nuclear Cross Sections Advisory Group

This group is appointed on a yearly basis to make a continuing review of the Commission's program of nuclear cross-section measurements, and to evaluate the needs for cross-section information in the various activities of the Commission. The following members were appointed to serve from July 1960 to July 1961.

Dr. VANCE L. SAILOR, *chairman;* Brookhaven National Laboratory, Upton, Long Island, N.Y.

Dr. JACOB BENVENISTE, Lawrence Radiation Laboratory, Livermore, Calif.

Dr. TOM W. BONNER, Department of Physics, Rice Institute, Houston, Tex.

Dr. ROBERT E. COTE, Argonne National Laboratory, Argonne, Ill.

Dr. BENJAMIN C. DIVEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. REX G. FLUHARTY, Phillips Petroleum Co., Idaho Falls, Idaho

Dr. STANLEY G. FULTZ, Lawrence Radiation Laboratory, Livermore, Calif.

Dr. HERBERT GOLDSTEIN, Columbia University, New York, N.Y.

Dr. JOHN A. HARVEY, Oak Ridge National Laboratory, Oak Ridge, Tenn.

PHILIP B. HEMMIG, division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. RICHARD L. HENKEL, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. GEORGE A. KOLSTAD, division of research, U.S. Atomic Energy Commission, Washington, D.C.

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Dr. HENRY W. NEWSON, department of physics, Duke University, Durham, N.C.

Dr. GEORGE L. ROGOSA, division of research, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ALAN B. SMITH, Argonne National Laboratory, Argonne, Ill.

Dr. HARVEY B. WILLARD, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. JOHN R. STEHN, *secretary;* Brookhaven National Laboratory, Upton, Long Island, N.Y.

Patent Advisory Panel

This panel was appointed in January 1947. It makes informal reports and recommendations to the Commission and its staff on various questions of policy and procedure relating to patents and inventions.

JOHN A. DIENNER, firm of Brown, Jackson, Boettcher & Dienner, Chicago, Ill.

JOHN C. STEDMAN, University of Wisconsin Law School, Madison, Wis.

Personnel Security Review Board

This board was appointed in March 1949 primarily to review specific personnel security cases which arise under the Commission's administrative review procedure and to make recommendations concerning them to the General Manager. The board also advises the Commission on the broader considerations regarding personnel security, such as criteria for determining eligibility for security clearance and personnel security procedures.

GANSON PURCELL, chairman; Purcell & Nelson, Washington, D.C.

DR. PAUL E. KLOPSTEG, special consultant, National Science Foundation, Washington, D.C.

JOHN J. WILSON, firm of Whiteford, Hart, Carmody & Wilson, Washington, D.C.

Stack Gas Problem Working Group

The appointment of this group was authorized in May 1948 to advise the Atomic Energy Commission and its contractors on problems in the treatment and control of gaseous effluents. The group meets formally at irregular intervals but renders continuing assistance in the field of air cleaning through specific research and development work directly by individual members and by individual consulting advice to the various Commission installations.

Dr. J. A. LIEBERMAN, *chairman;* division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. PHILIP DRINKER, Professor of industrial hygiene, Harvard University School of Public Health, Boston, Mass.

Dr. LYLE I. GILBERTSON, director, research and engineering department, Air Reduction Co., Inc., Murray Hill, N.J.

A. E. GORMAN, consultant, U.S. Atomic Energy Commission, Washington, D.C.

Dr. H. FRASER JOHNSTONE, professor of chemical engineering, University of Illinois, Urbana, Ill.

Dr. CHARLES E. LAPPLE, Stanford Research Institute, Menlo Park, Calif.

Dr. WILLIAM P. YANT, director of research and development, Mine Safety Appliance Co., Pittsburgh, Pa.

Dr. ABEL WOLMAN, head, department of sanitary engineering and water re- [illegible] The Johns Hopkins University, Baltimore, Md.

APPENDIX 3

Major Research and Development Installations of the U.S. Atomic Energy Commission

Ames Laboratory (Iowa State University of Science and Technology, contractor), Ames, Iowa

Director	Dr. Frank H. Spedding
Associate Director	Dr. H. A. Wilhelm
Assistant to Director	Dr. Adolf F. Voigt
Assistant to Director	Morton S. Smutz
Business Manager	Alex E. Edwards
Assistant Director for Administration	Cyril W. Kupferberg

Argonne Cancer Research Hospital (University of Chicago, contractor), Chicago, Ill.

Director	Dr. Leon O. Jacobson
Associate Director	Dr. Robert J. Hasterlik

Argonne National Laboratory (University of Chicago, contractor), Chicago, Ill.

Director	Dr. A. V. Crewe
Deputy Director	Dr. Louis A. Turner
Associate Director for Education	Dr. Frank E. Myers
Associate Director for High Energy Physics	Dr. Roger H. Hildebrand
Assistant Director	Dr. James R. Gilbreath
Business Manager	John H. McKinley
Manager, Technical Services	John T. Bobbitt

Associated Midwest Universities:

- Battelle Memorial Institute
- Carnegie Institute of Technology
- Case Institute of Technology
- Illinois Institute of Technology
- Indiana University
- Iowa State University
- Kansas State University
- Loyola University (Chicago, Ill.)
- Marquette University
- Mayo Foundation
- Michigan College of Mining and Technology
- Michigan State University
- Northwestern University
- Ohio State University
- Oklahoma State University
- Purdue University
- St. Louis University
- State University of Iowa
- University of Chicago
- University of Cincinnati
- University of Illinois
- University of Kansas
- University of Michigan
- University of Minnesota
- University of Missouri
- University of Nebraska
- University of Notre Dame
- University of Wisconsin
- Washington University (St. Louis, Mo.)
- Wayne University
- Western Reserve University

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President, Board of Directors	W. L. EVERITT
Vice President	W. R. MARSHALL
Executive Director	J. H. ROBERSON
Treasurer	A. T. SCHMEHLING

Brookhaven National Laboratory (Associated Universities, Inc., contractor) Upton, Long Island, N.Y.

Chairman, Board of Trustees	Dr. CARL C. CHAMBERS
President, AUI	Dr. I. I. RABI
Laboratory Director	Dr. MAURICE GOLDHABER
Deputy Director	Dr. GERALD F. TAPE
Assistant Director	Dr. R. CHRISTIAN ANDERSON
Assistant Director	Dr. CHARLES E. FALK
Assistant Director	SAMUEL M. TUCKER

The participating institutions are:

Columbia University
Cornell University
Harvard University
The Johns Hopkins University
Massachusetts Institute of Technology
Princeton University
University of Pennsylvania
University of Rochester
Yale University

Hanford Laboratories—Hanford Atomic Products Operation (General Electric Co., contractor), Richland, Wash.

Manager	H. M. PARKER
Director, Biology Department	Dr. H. A. KORNBERG
Principal Section Manager	Dr. F. W. ALBAUGH
Principal Section Manager	Dr. P. F. GAST
Principal Section Manager	Dr. W. H. REAS

Knolls Atomic Power Laboratory (General Electric Co., contractor), Schenectady, N.Y.

General Manager and Manager, Natural Circulation Reactor (NCR).	B. H. CALDWELL, JR.
Manager, D1G Project	K. A. KESSELRING
Manager, NCR Project	J. D. SELBY
Manager, SAR Project	E. C. RUMBAUGH

Los Alamos Scientific Laboratory (University of California, contractor), Los Alamos, N. Mex.

Director	Dr. NORRIS E. BRADBURY
Technical Associate Director	Dr. DAROL K. FROMAN

Mound Laboratory (Monsanto Chemical Co., contractor), Miamisburg, Ohio

Project Director (President, Monsanto Chemical Co.)	H. K. NASON
	DAVID L. SCOTT

National Reactor Testing Station (NRTS) Idaho Falls, Idaho (Three Contractors)

Phillips Petroleum Co., Atomic Energy Division, Idaho Falls, Idaho

Project Manager	Dr. R. L. Doan
Assistant Manager, Operations	J. P. Lyon
Assistant Manager, Technical	J. R. Huffman
Assistant Manager, Administration	L. L. Leedy

Combustion Engineering, Inc., Nuclear Division, Windsor, Conn.

Project Manager	W. B. Allred
Site Administrator	E. W. Woollacott

Aerojet General Corp. and Aerojet General Nucleonics, San Ramon, Calif.

Operations Manager	R. H. Chesworth
Operations Superintendent	D. C. King
Administrative Supervisor	C. Nedrow

Oak Ridge Institute of Nuclear Studies (contractor), Oak Ridge, Tenn.

President of Institute	Dr. Paul M. Gross
Executive Director of Institute	Dr. William G. Pollard
Chairman of Council	Dr. R. T. Lagemann
Vice Chairman of Council	Dr. Eric Rogers

The sponsoring universities of the Institute are:

- Agricultural and Mechanical College of Texas
- Alabama Polytechnic Institute
- Catholic University of America
- Clemson Agricultural College
- Duke University
- Emory University
- Fisk University
- Florida State University
- Georgia Institute of Technology
- Louisiana State University
- Meharry Medical College
- Mississippi State College
- North Carolina State College
- North Texas State College
- Rice Institute
- Southern Methodist University
- Tulane University of Louisiana
- Tuskegee Institute
- Texas Woman's University
- University of Alabama
- University of Arkansas
- University of Florida
- University of Georgia
- University of Kentucky
- University of Louisville
- University of Maryland
- University of Miami
- University of Mississippi
- University of North Carolina
- University of Oklahoma
- University of Puerto Rico
- University of South Carolina
- University of Tennessee
- University of Texas
- University of Virginia
- Vanderbilt University
- Virginia Polytechnic Institute
- West Virginia University

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Oak Ridge National Laboratory (Union Carbide Nuclear Co., Division of Union Carbide Corp., contractor) Oak Ridge, Tenn.

Director	A. M. WEINBERG
Deputy Director	J. A. SWARTHOUT
Associate Director	H. G. MACPHERSON
Assistant Director	G. E. BOYD
Assistant Director	R. W. JOHNSON
Assistant Director	W. H. JORDAN
Assistant Director	M. E. RAMSEY
Assistant Director	A. H. SNELL
Assistant Director	C. E. WINTERS

Raw Materials Development Laboratory (National Lead Co., contractor), Winchester, Mass.

Technical Director and Manager	CHARLES K. MCARTHUR

Sandia Laboratory (Sandia Corp., contractor), Sandia Base, Albuquerque, N. Mex.

President	S. P. SCHWARTZ
Vice President, Weapon Programs	R. W. HENDERSON
Vice President, Research	G. C. DACEY
Vice President, Personnel	R. B. POWELL
Vice President, Administration	C. W. CAMPBELL
Vice Presidents, Development	E. H. DRAPER
	G. A. FOWLER
Vice Presdent, Engineering for Manufacturing	R. A. BICE

University of California at Los Angeles, Laboratory of Nuclear Medicine and Radiation Biology (University of California, contractor), Los Angeles, Calif.

Director	Dr. JOSEPH F. ROSS
Assistant Director	T. G. HENNESSY
Project Manager	H. B. THOMPSON

University of California, Medical Center, Radiological Laboratory (University of California, contractor), San Francisco, Calif.

Director	Dr. ROBERT S. STONE
Associate Director	Dr. GAIL D. ADAMS

University of California E. O. Lawrence Radiation Laboratory (University of California, contractor), Berkeley, Calif.

Director	Dr. EDWIN M. MCMILLAN
Associate Director and Director, Livermore Laboratory.	Dr. JOHN S. FOSTER, Jr.
Associate Director and Director, Donner	Dr. JOHN H. LAWRENCE

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Associate Director	Dr. Edward Teller
Associate Director	Dr. Robert L. Thornton
Associate Director	Dr. Harold A. Fidler
Business Manager and Managing Engineer	Wallace B. Reynolds
Livermore Associate Directors:	
Chemistry & Acting Associate Director for Testing.	Dr. Roger E. Batzel
Sherwood	Dr. Chester M. Van Atta
Support	Duane C. Sewell
Pluto	Dr. Theodore C. Merkle
Donner:	
Assistant Director	Dr. James L. Born
Assistant Director	Dr. Hardin B. Jones

University of Rochester Atomic Energy Project (University of Rochester, contractor), Rochester, N.Y.

Director	Dr. Henry A. Blair
Business Manager	C. S. Thompson

Nevada Test Site, Las Vegas, Nev.

Eniwetok Proving Ground, Marshall Islands

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APPENDIX 4

Radioactive Isotopes Distribution Data and Development Contracts

RADIOISOTOPE DISTRIBUTION BY OAK RIDGE NATIONAL LABORATORY

(Includes project transfers, subsidy payments, etc.)

Radioisotopes	Aug. 2, 1946–Dec. 31, 1960		Jan. 1,–Nov. 30, 1961		Total to Nov. 30, 1961	
	Activity (curies)	Shipments	Activity (curies)	Shipments	Activity (curies)	Shipments
Carbon 14	109	3,453	40	310	149	3,763
Cesium 137	130,959	1,530	48,535	199	179,494	1,729
Cobalt 60	822,312	2,201	235,298	130	1,057,610	2,331
Hydrogen 3	100,950	1,135	43,642	216	144,592	1,351
Iodine 131	7,117	46,521	177	1,838	7,294	48,359
Iridium 192	39,959	878	5,808	90	45,767	968
Krypton 85	10,075	416	4,475	165	14,550	581
Phosphorus 32	1,807	28,569	130	1,934	1,937	30,503
Promethium 147	3,677	403	862	78	4,539	481
Strontium 90	899	859	98,326	101	99,225	960
All others	1,715	58,364	912	6,846	2,627	65,210
Total	1,119,579	144,329	438,205	11,907	1,557,784	156,236

NOTE.—This table does not include several thousand curies of radioisotopes produced and distributed directly from other AEC facilities such as Mound Laboratory or Brookhaven National Laboratory nor from reactors owned by private industrial firms and universities. Radioisotopes made in other countries and imported into United States are also not included.

RADIOISOTOPE SALES FROM OAK RIDGE NATIONAL LABORATORY

Type of sales	Aug. 2, 1946–Dec. 31, 1960	Jan. 1–Nov. 30, 1961	Total to Nov. 30, 1961
Domestic	12,902,366	1,301,037	14,203,403
Foreign	1,750,616	286,407	2,037,023
Total commercial sales	14,652,982	1,587,444	16,240,426
Project transfers	1,932,922	369,328	2,302,250
Medical subsidy [1]	3,440,433	243,116	3,683,549
Technical cooperation program			
Local sales to ORNL	788,161	146,545	934,706
Civilian defense			
Special sales [2]		422,091	422,091
Subtotal	6,161,516	1,181,080	7,342,596
Total	20,814,498	2,768,524	23,583,022

[1] Medical subsidy terminated June 30, 1961.

[2] Special sales category added July 1, 1961.

NOTE.—This table does not include sales by private commercial firms who act as secondary suppliers, other AEC facilities such as Mound Laboratory and Brookhaven National Laboratory, private firms and universities who own reactors, nor imports into the United States from other countries.

LOCATION AND TYPE OF NEW LICENSEES

December 1, 1960–November 30, 1961

[PP—Private Practice; IR—Industrial Radiography; CD—Civil Defense]

States	Medical institutions and physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutes	Other	Total
	PP			IR		CD				
Alaska	1					3	1			4
Alabama	8	6	1	1		3	2			12
Arizona	6	4		6		5	4		1	16
Arkansas				1						1
California	47	39	4	46	4	9	3	1	4	111
Colorado	4	1	1	5	1	6	4			16
Connecticut	5	5	1	4	1	3	2			12
Delaware				2		1	1			2
District of Columbia	6	5		1		6	4		1	14
Florida	10	7	1	6	2	16	14			23
Georgia	6	5		2		3	3			11
Hawaii	1	1		3		1	1			5
Idaho	2	2		2	2	2	1			8
Illinois	17	10		19		10	9		1	47
Indiana	9	7	2	7	1	3	3		1	22
Iowa	3	1	1	2	1	2	2			8
Kansas	1		1	2	1	8	8			12
Kentucky	5	4		2		2	1			9
Louisiana	4	2	3	4		4	2	1		16
Maine	4	1							1	5
Maryland	9	6		2		5	2		1	17
Massachusetts	10	6		20	1	8	8	1		39
Michigan	17	13	2	3		4	2	2		28
Minnesota	9	6	3	6		4	4			22
Mississippi	3	3		2		2	2			7
Missouri	4	3		3		7	7			14
Montana	1		1	2		1				5
Nebraska	1	1	1			2	2			4
Nevada	1	1		2		1	1			4
New Hampshire			1	1		1	1			3
New Jersey	21	12	1	24	3	8	5	1		55
New Mexico	2	2	2	4		2	1			10
New York	49	36	7	46	3	18	13		1	173
North Carolina	9	7	1	2		10	10			22
North Dakota	2	2								2
Ohio	16	12	1	17	1	12	11			46
Oklahoma	6	1	2	3		6	6			17
Oregon	3	2	3	2	1	9	9			17
Panama										
Pennsylvania	13	6	4	29	2	10	8		2	56
Puerto Rico	2	1								2
Rhode Island	1	1	1			2	1			4
South Carolina	3	3	1			3	3			7
South Dakota	3	2	1							4
Tennessee	3	2		4		3	3			10
Texas	20	16	5	21	2	20	17			26
Utah				7	1	1	1			4
Vermont	1		1	1						3
Virginia	5	2	1	6	1	3				18
Washington	8	6	1	7	3	13	12			29
West Virginia	2	2	1	2		6	4			11
Wisconsin	4	2	2	3	2	3	3			13
Wyoming				4	1					4
Total	367	256	58	338	34	251	201	6	13	1,[illegible]

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LOCATION AND TYPE OF LICENSEES

February 1956 through November 1961

[PP—Private Practice; IR—Industrial Radiography; CD—Civil Defense]

States	Medical institute and physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutes	Other	Total
	PP			IR		CD				
Alaska	2	1	1	0	0	10	5	0	0	13
Alabama	39	22	4	18	8	16	9	1	0	78
Arizona	22	14	3	7	0	18	16	0	1	51
Arkansas	22	14	1	8	0	2	2	0	0	33
California	328	211	18	245	49	64	21	3	9	667
Colorado	32	10	7	27	4	31	25	1	3	101
Connecticut	38	19	6	48	13	15	11	1	1	109
Delaware	4	1	1	12	2	6	6	0	0	23
District of Columbia	27	11	4	5	2	34	17	2	2	74
Florida	84	54	5	21	7	32	25	0	1	143
Georgia	44	21	5	11	6	20	16	0	0	80
Hawaii	15	11	1	8	2	5	2	1	0	30
Idaho	6	3	2	3	3	2	1	0	0	13
Illinois	133	42	7	130	18	43	35	4	3	320
Indiana	58	29	9	46	14	18	18	0	3	134
Iowa	49	26	12	12	4	25	24	0	1	99
Kansas	26	10	3	18	6	18	17	0	0	65
Kentucky	31	17	4	13	3	22	18	0	0	70
Louisiana	39	17	6	32	14	11	9	2	1	91
Maine	18	7	2	7	2	4	3	0	1	32
Maryland	37	16	7	24	7	32	19	2	1	103
Massachusetts	83	29	20	107	15	22	17	6	3	241
Michigan	105	46	11	56	16	52	43	2	2	228
Minnesota	46	19	13	22	5	110	109	0	0	191
Mississippi	13	6	3	9	4	10	9	0	0	35
Missouri	83	39	6	31	8	30	28	0	1	151
Montana	13	4	3	3	0	2	1	0	0	21
Nebraska	21	10	2	4	1	27	27	0	1	55
Nevada	7	4	1	5	1	5	4	0	0	18
New Hampshire	12	2	4	7	2	10	9	0	0	33
New Jersey	106	58	2	139	22	30	24	2	1	280
New Mexico	18	10	6	16	1	7	2	0	0	47
New York	348	177	38	210	31	65	48	12	10	683
North Carolina	53	30	7	17	0	47	43	0	1	125
North Dakota	8	5	2	2	1	9	8	0	0	21
Ohio	149	74	13	123	36	60	49	3	2	350
Oklahoma	44	30	5	31	10	14	12	1	0	95
Oregon	32	20	7	10	7	34	31	1	0	84
Panama	1	0	0	0	0	0	0	0	0	1
Pennsylvania	139	47	19	170	56	119	104	6	4	457
Puerto Rico	9	4	3	1	0	2	2	0	0	15
Rhode Island	8	2	4	8	1	6	5	0	0	26
South Carolina	18	11	3	6	3	14	11	0	0	41
South Dakota	17	9	4	2	0	11	11	0	0	34
Tennessee	41	19	5	30	4	13	11	0	1	90
Texas	172	114	20	121	38	42	34	4	2	361
Utah	9	1	4	16	3	15	11	0	0	44
Vermont	11	7	2	3	0	1	1	0	0	17
Virginia	36	13	7	36	7	20	10	0	1	100
Washington	42	25	9	22	9	38	33	1	0	112
West Virginia	25	14	2	18	2	41	38	0	0	86
Wisconsin	61	23	6	36	17	5	3	3	1	112
Wyoming	4	1	1	7	1	15	13	0	2	29
Total	2,788	1,409	340	1,963	465	1,304	1,050	58	59	6,512

RADIOISOTOPES AND PROCESS RADIATION DEVELOPMENT CONTRACTS

Armour Research Foundation of Illinois Institute of Technology. (1) A study of the feasibility of using scintillating fibers for low energy beta counting. (2) Scintillation spectrometer measurements of capture gamma rays from natural elements. (3) Evaluation of world isotope and radiation technology.

Battelle Memorial Institute (Columbus, Ohio). Development and evaluation of safety performance criteria for sealed radiation sources.

Booz-Allen Applied Research, Inc. (Glenview, Ill.). Development of krypton 85 clathrate technique to measure oxidation-reduction products in the liquid phase.

University of California (Davis). Research on radiation pasteurization of fruits and vegetables.

University of California (Berkeley). Summer institute in radiation-isotopes technology.

Continental Can Co., Inc. (Chicago). Survey of present status and research and development requirements regarding packaging materials for low-dose radiation processed foods.

U.S. Department of the Interior, Bureau of Commercial Fisheries. An analysis of market factors affecting radiation processing of fish.

U.S. Department of the Interior, Bureau of Commercial Fisheries. Study of the effect on the essential amino acids and B-vitamins from radiation pasteurization of haddock fillets and soft shell clam meats.

Louisiana State University (Baton Rouge). Summer institute in radiation-isotope technology.

The Martin Co. (Baltimore). A study of semiconductor and thermoelement research and development directed towards radioisotopic power.

Massachusetts Institute of Technology (Cambridge). A study of the effects of radiation pasteurization on the storage life extension of soft-shelled clams and haddock fillets.

University of Michigan (Ann Arbor). Summer institute in uses of radioisotopes in research and technology.

National Sanitation Foundation (Ann Arbor). A study of the radiation exposure of persons working with reactor produced radioisotopes.

Nuclear Science & Engineering Corp. (Pittsburgh). A study of isotope dilution techniques for assay of food additives.

University of Oklahoma (Norman). Summer institute in isotope and nuclear reactor technology.

Parametrics, Inc. (Saxonville, Mass.). (1) The development of krypton 85 as a universal tracer. (2) The investigation of radioisotope techniques for atmospheric density measurements.

Renewed During 1961

Armour Research Foundation. (1) Research study on neutron interactions in matter as related to image formation. (2) Study radiation reaction mechanism producing high value halogenated aromatic compounds. (3) Investigation of nuclear resonance techniques for performing physical measurements.

Battelle Memorial Institute. Study of structural and compositional factors influencing radiation induced polymerization reactions.

University of Chicago. Radioisotope research, development and related activities.

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olidation Coal Co., Inc. (Pittsburgh). Research and development of techniques for labeling relatively high molecular weight coal-product hydrocarbon mixtures with tritium.

rgia Technological Research Institute (Atlanta). Investigation of amalgam-salt system to determine the feasibility of this system for enrichment of calcium 46 and development of an activation analysis technique for calcium enrichment determination. In addition, as a sub-task, a systematic analysis of the strontium, barium and calcium solvent extraction system using a di-2-ethylhexyl phospheric acid is being conducted. (2) Development of a method of using radiotracers to measure uniformity of mixture in bituminous concrete. (3) Study of the radiation induced cyanogenation of organic compounds.

S. Department of the Interior, Bureau of Mines. Research on radioactive ruthenium as a tracer in ground water studies.

H. Johnston Laboratories, Inc. (Baltimore). (1) Development of isotope techniques in stream pollution, especially *in situ* tracers. (2) Mass spectrometric of fast primary ion reactions.

brary of Congress. Continue the monitoring-type survey of world literature on industrial radioisotopes applications.

iversity of Oklahoma Research. Study of sequestration of metal ions in brine using radioisotopes.

diation Applications, Inc. (Long Island, N.Y.). (1) Study of the accelerative effects of additives on radiation induced graft polymerization. (2) To study the mechanism of radiation induced gelation in monomer-polymer mixtures.

esearch Triangle Institute of North Carolina (Durham). Low-level tracer studies, fission product uses, soil moisture studies and quality control techniques.

echnical Research Group (Syosset, L.I., N.Y.). Synthesis of semi-conductor materials by radiation induced reactions.

exas A. & M. Research Foundation (College Station). Development of computer coupled activation analysis techniques.

extile Research Center (Raleigh, N.C.). Applications of nuclear radiation and radioisotope techniques to textile materials and processes.

racerlab, Inc. (Waltham, Mass.). Development of radiochemical exchange systems and study of clathrate compounds.

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APPENDIX 5

Commission-Owned Patents

PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING [1]

The following 250 U.S. Letters Patents owned by the United States Government as represented by the Atomic Energy Commission are in addition to the 2,[illegible] patents listed in the 1960 annual report. The patents listed are available for licensing. The total number of patents available for licensing is 2,734. Licenses are granted on a nonexclusive, royalty-free basis.

Patent No.	Title	Patentee
2,676,309	High Frequency Power Transmission Line for Cyclotrons and the Like.	W. J. Armstrong, Cedar Rapids, Iowa.
2,842,436	Selective Rejection of Iron and Aluminum in Hydrometallurgical Recovery of Metals.	J. Orndorff, Pittsburgh, Pa.; A. J. Beyer, White Plains, N.Y.
2,963,223	Multiple Input Binary Adder Employing Magnetic Drum Digital Computing Apparatus.	E. H. Cooke-Yarborough, Longworth, England.
2,964,124	Separation of Gases by Diffusion	R. E. Peierls, Birmingham, England; F. E. Simon, and H. S. Arms, Oxford, England.
2,964,130	Separation of Ruthenium Compounds from Gaseous Mixtures.	B. J. Newby, Idaho Falls; D. A. Hanson, Shelly, and C. E. May, Idaho Falls, Idaho.
2,964,710	Accelerator Target Positioner and Control Circuit Therefor.	K. F. Stone, Berkeley, Calif.; R. J. Form, Richmond, Calif.; W. W. Olson, El Sobrante and D. S. Cagle, Oakland, Calif.
2,965,781	Neutron-Counter	S. B. Gunst, Baldwin, Pa.; R. T. Bayard, Whitehall, Pa.
2,965,840	Metal Resistivity Measuring Device	R. G. Meyers, Orland Park, Ill.; C. J. Renkin, Jr., Downers Grove, Ill.
2,966,709	Casting Furnaces	R. H. Ruppel, Granite City, Ill.; C. E. Winters, Oak Ridge, Tenn.
2,966,794	Deflection Pressure Tester	C. M. Cooper, Newark, Del.
2,966,799	Sensitive Pressure Gauge	W. P. Ball, Livermore, Calif.
2,967,141	Neutronic Reactor Fuel Element	M. L. Picklesimer, Knoxville; W. C. Thurber, Oak Ridge, Tenn.
2,967,209	Recovery of Ruthenium Values	W. E. Crummitt and W. H. Hardwick, Deep River, Canada
2,967,257	Ion Pump	M. Milleron, Berkeley, Calif.
2,967,809	Method and Apparatus for Controlling Direct-Cycle Neutronic Reactors	G. A. Reed, E. Natick, Mass.
2,967,811	Fuel Elements for Thermal-Fission Nuclear Reactors	O. Flint, Strand, London, England
2,967,812	Neutronic Reactor Fuel Composition	W. C. Thurber, Oak Ridge, Tenn.
2,967,943	Gaseous Discharge Device	J. D. Gow, Berkeley, Calif.
2,968,007	Automatic Frequency Control System	C. F. Hansen, Bountiful, Utah; J. D. Salisbury, Livermore, Calif.
2,968,183	Sampling System	B. A. Hannaford, C. L. Segaser and C. L. Terry, Oak Ridge, Tenn. and R. R. Rosenberg, Pittsburgh, Pa.
2,968,547	Production of Plutonium Metal	W. L. Lyon and R. H. Moore, Richland, Wash.

[1] Patents listed as of November 21, 1961. Applicants for licenses should apply to Assistant General Counsel for Patents, Office of the General Counsel, U.S. Atomic Energy Commission, Germantown, Md., identifying the subject matter by patent number and title.

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PATENTS ISS

Patent No.	
2,968,601	Fuel Eleme
2,968,602	Reactor-Fla
2,968,715	Fusion Wel
2,968,731	Beta-Gamm
2,969,307	Method of sionable N
2,969,308	Method of Neutron I
2,969,309	Neutronic R of Manufa
2,969,310	Neutronic F
2,969,311	Means for Reactions
2,969,312	Type Fuel I
2,969,313	Nuclear Re
2,969,507	Blocking O Circuit.
2,969,712	High Temp
2,969,915	Electronic N
2,970,035	Separation by Adsor phate.
2,970,050	Process for Uranium.
2,970,885	Corrosion R
2,971,153	Microwave Measuren
2,971,907	Filter Medi
2,973,492	Pulse Inver
2,974,006	Direct Con Uranium
2,974,012	Preparation Purity.
2,974,096	Fuel Slug R
2,974,248	Neutron-In
2,974,251	Method an Emission.
2,975,113	Method of Capsule.
2,975,114	Reactor
2,975,115	Bellows Se
2,975,116	Neutronic I
2,975,117	Fast Neutr
2,975,119	Vertical Ro
2,975,414	Radio Ran
2,975,770	Steam Gen
2,975,912	Charging D
2,976,121	Processing
2,976,227	Neutronic I
2,977,194	Method of Nuclear

PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—continued

Number	Title	Patentee
[illegible] 801	Fuel Element for Neutronic Reactors	T. C. Evans, Grundy Center, Iowa; E. G. Beasley, Jr., Arlington, Va.
[illegible] 802	Reactor-Flash Boiler-Flywheel Power Plant	E. Loeb, Silver Spring, Md.
[illegible] 715	Fusion Welding Method and Apparatus	W. L. Wymand and W. I. Steinkamp, Richland, Wash.
[illegible] 731	Beta-Gamma Personnel Dosimeter	D. M. Davis, Corryton; E. D. Gupton, Oak Ridge, and J. C. Hart, Lenoir City, Tenn. and A. P. Hull, Kingston, N.J.
[illegible] 307	Method of Testing Thermal Neutron Fissionable Material for Purity	H. L. Anderson, Hartford, Conn.; E. Fermi (deceased)
[illegible] 308	Method of Producing Energetic Plasma for Neutron Production.	P. R. Bell, R. J. Mackin, Jr., and A. Simon, Oak Ridge, Tenn.
[illegible] 309	Neutronic Reactor Fuel Element and Method of Manufacture.	H. M. Finniston and O. S. Plail, London, England.
[illegible] 310	Neutronic Reactor Systems	J. J. Goett (deceased).
[illegible] 311	Means for Producing Plutonium Chain Reactions.	E. P. Wigner and A. M. Weinberg, Oak Ridge, Tenn.
[illegible] 312	Type Fuel Element	H. O. Monson, Elmhurst, Ill.
[illegible] 313	Nuclear Reactor	J. J. Grebe, Midland, Mich.
[illegible] 507	Blocking Oscillator Double Pulse Generator Circuit.	J. A. Haase, Evanston, Ill.
[illegible] 712	High Temperature Microscope and Furnace	D. M. Olson, Los Alamos, N. Mex.
[illegible] 915	Electronic Multiplier	D. M. Collier and L. A. Meeks, Oak Ridge, Tenn.; J. P. Palmer, Stony Brook, N.Y.
[illegible] 035	Separation of Plutonium Ions from Solution by Adsorption on Zirconium Pyrophosphate.	R. W. Stoughton, Oak Ridge, Tenn.
[illegible] 050	Process for Removing Noble Metals from Uranium.	J. B. Knighton, Nixon, N.J.
[illegible] 885	Corrosion Reduction	S. Greenberg, Chicago, Ill.; R. D. Misch, Whiting, Ind.; W. E. Ruther, Skokie, Ill.
[illegible] 153	Microwave Horns and Circuitry for Plasma Measurements.	C. B. Wharton, Pleasanton, and A. L. Gardner, Livermore, Calif.
[illegible] 907	Filter Media and Method of Making	W. J. Smith, Arlington, Mass.
[illegible] 492	Pulse Inverting Transformer	D. A. Mack, Berkeley, Calif.
[illegible] 006	Direct Conversion of Uranium Turnings to Uranium Tetrafluoride.	O. E. Fry, Baton Rouge, La.
[illegible] 012	Preparation of Beryllium Oxide of High Purity.	R. Cooperstein and G. R. Anderson, Cincinnati, Ohio.
[illegible] 096	Fuel Slug Rupture Detector	R. S. Paul, Richland, Wash.
[illegible] 248	Neutron-Insensitive Beta-Gamma Dosimeter	J. A. Auxier, R. E. Zedler, Oak Ridge, and G. S. Hurst, Knoxville, Tenn.
[illegible] 251	Method and Means for Increasing Electron Emission.	A. J. Bureau, Ames, Iowa.
[illegible] 113	Method of an Irradiation Transmutation Capsule.	C. M. Gordon, Danville, Calif.
[illegible] 114	Reactor	S. K. Allison, Chicago, Ill.
[illegible] 115	Bellows Seal on Reactor Coolant Tube	E. P. Wigner, Princeton, N.J.; L. A. Ohlinger and G. J. Young, Chicago, Ill.
2,973,116	Neutronic Reactor	F. Daniels, Chicago, Ill.
2,973,117	Fast Neutron Reaction System	W. H. Zinn, Dunedin, Fla.
2,973,119	Vertical Rod Drive Mechanism	C. D. Emmons, Richland, Wash
2,973,414	Radio Ranging Device	R. W. Bogle, Silver Springs, Md.
2,973,770	Steam Generator	H. O. Monson, Elmhurst, Ill.
2,975,912	Charging Device	S. L. Handforth, Wilmington, Del.
2,976,121	Processing of Cesium Metal Cyanides	O. H. Koski, Richland, Wash.
2,976,227	Neutronic Reactor	J. A. Wheeler, Princeton, N.J.
2,977,194	Method of Reducing Aqueous Radioactive Nuclear Wastes to Solid Form.	J. W. Loeding, Brookfield, and A. A. Jonke, Elmhurst, Ill.

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PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—continued

Patent No.	Title	Patentee
2, 977, 204	Method of Improving Corrosion Resistance of Zirconium.	D. W. Shannon, Richland, Wash.
2, 977, 220	Process of Producing Uranium	T. K. Wood (deceased).
2, 977, 297	Reactor Fuel Assembly	E. A. Evans, R. J. Anicetti and W. E. Roake, Richland, Wash.
2, 977, 814	Two-Speed Device	G. S. Brunson, Jr., Idaho Falls, Idaho.
2, 978, 118	Manipulator for Slave Robot	R. C. Goertz, Downers Grove, Ill.; J. H. Grimson, Villa Park and F. A. Kohut, Westmont, Ill.
2, 978, 294	Solvent Extraction Process for Protactinium	E. K. Hyde and L. I. Katzin, Chicago; Michael J. Wolf, Peoria, Ill.
2, 978, 295	Recovery of Plutonium by Carrier Precipitation.	R. H. Goeckermann, Princeton, N.J.
2, 978, 358	Method of Obtaining Uniform Coatings on Graphite.	I. E. Campbell, Gahanna, Ohio
2, 978, 398	Neutronic Reactor	H. E. Metcalf and H. W. Johnson, Chicago, Ill.
2, 979, 379	Extraction of Uranium	E. G. Schmieding, Pampa, Tex., A. E. Ruehle, Pacific, Mo.
2, 979, 399	Preparation of Compacts Made from Uranium and Berryllium.	R. P. Angier, New York, N. Y.
2, 979, 620	Air Radioactivity Monitor	R. L. Brandshaw, Knoxville, Tenn.; J. W. Thomas, St. Joseph, Mich.
2, 979, 635	Clashing Beam Accelerator	R. J. Burleigh, Berkeley, Calif.
2, 980, 905	Radio Ranging Device	J. W. Gratian and A. C. Gratian, Rochester, N.Y.; R. T. Nieset, New Orleans, La.; M. E. Bourns, Altadena, Calif. and Horace R. Crane, Ann Arbor, Mich.
2, 981, 591	Method For Recovering Plutonium Values From Solution Using A Bismuth Hydroxide Carrier Precipitate.	B. F. Faris, Oak Ridge, Tenn.
2, 981, 592	Method and Apparatus For Calcining Salt Solutions	S. Lawroski, Naperville; A. A. Jonke, Elmhurst, and R. G. Taecker, Naperville, Ill.
2, 981, 643	Process For Descaling and Decontaminating Metals.	R. D. Baybarz, Knoxville, Tenn.
2, 981, 672	Nuclear Reactor Fuel Element	W. E. Kingston, Bayside, N.Y.
2, 982, 599	Production of Plutonium Fluoride From Bismuth Phosphate Precipitate Containing Plutonium Values.	H. S. Brown, Chicago, Ill.; E. G. Bohlmann, Worthington, Ohio
2, 982, 600	Uranium Decontamination With Respect to Zirconium.	S. Vogler and M. Beederman, Chicago, Ill.
2, 982, 601	Separation of Uranyl and Ruthenium Values By the Tributyl Phosphate Extraction Process.	A. S. Wilson, Richland, Wash.
2, 982, 603	Preparation of Anhydrous Cerium Chloride Uranium Bromide, or Plutonium Fluoride.	K. M. Harman, Glendale, Calif.; E. Wichers, Washington, D.C.
2, 982, 604	Preparation of Neptunium Hexafluoride	G. T. Seaborg, Berkeley, Calif.; H. W. Brown, Chicago, Ill.
2, 982, 702	Pretreating Uranium for Metal Plating	R. F. Wehrmann, Waukegan, Ill.
2, 982, 708	Fuel for Neutronic Reactors and Process of Making.	B. M. Abraham, Oak Park and H. E. Flotow, Bellwood, Ill.
2, 982, 709	Neutronic Reactor Design to Reduce Neutron Loss.	F. T. Miles, Blue Point, N.Y.
2, 982, 710	Food Irradiation Reactor	C. F. Leyse, Manchester, Mo., and G. R. Putnam, Lynchburgh, Va.
2, 982, 711	System for Unloading Reactors	A. C. Rand, Jr., Stoneham, Mass.
2, 982, 713	Merchant Marine Ship Reactor	M. F. Sankovich, Arlington, Mass.; J. F. Mumm, D. C. North, Jr., H. R. Rock, and D. K. Gestson, Lynchburgh, Va.
2, 982, 785	Cesium Recovery	T. R. McKenzie, Pasco, and W. W. Schulz

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PATENTS ISSU

Patent No.	
2, 982, 917	Method and A Particle Bea
2, 983, 042	Tube Splitting
2, 983, 144	Electronic Biv
2, 983, 145	Specific Heat I
2, 983, 658	Heterogeneous Small Uncla terial as Fue
2, 983, 659	Neutronic Rea
2, 983, 660	Fabrication of Nuclear Rea
2, 983, 663	Fuel Element
2, 983, 989	Broaching and
2, 984, 613	Fuel Element
2, 984, 744	Means for Visu
2, 984, 833	Super-Regener
2, 984, 995	Modified Ball
2, 985, 505	Salt Conversio
2, 985, 574	Overall Contro
2, 985, 824	Nondestructive
2, 986, 508	Neutronic Rea
2, 986, 509	Fuel Element f
2, 986, 510	Massive Leaka
2, 986, 772	Eccentric Roll Agent into S
2, 987, 375	Purification of
2, 987, 454	Electrolytic Pr
2, 987, 455	Method and Control.
2, 987, 458	Twisted Ribbo
2, 987, 816	Bonding Alum
2, 988, 429	Spiral Contra Column.
2, 988, 697	Linear Selsyn
2, 988, 812	Method of Fab
2, 988, 938	Control for Rol
2, 989, 367	Arsenate Carri Separating F radiated Ura Products.
2, 989, 368	Cesium Recove
2, 989, 453	Pressure Syster
2, 989, 454	Nuclear Reacto

PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—continued

Patent No.	Title	Patentee
[illegible] 917	Method and Apparatus for Pulsing a Charged Particle Beam.	K. Aaland, R. W. Kuenning, Livermore, Calif.; R. K. Harmon, Hayward, Calif.
[illegible] 042	Tube Splitting Apparatus	C. E. Frantz, W. E. Cawley, Richland, Wash.
[illegible] 144	Electronic Bivane Wind Direction Indicator	H. Moses, Park Forest, Ill.
[illegible] 145	Specific Heat Indicator	F. L. Horn, Sayville, N.Y.; J. E. Binns, Roslyn, N.Y.
[illegible] 658	Heterogeneous Nuclear Reactor Employing Small Unclad Bodies of Fissionable Material as Fuel.	H. H. Hyman, J. J. Katz, Chicago, Ill.
[illegible] 659	Neutronic Reactor Burial Assembly	M. Treshow, Del Mar, Calif.
[illegible] 660	Fabrication of Tube Type Fuel Element for Nuclear Reactors.	E. Loeb, Silver Spring; J. H. Nicklas, Riverdale, Md
[illegible] 663	Fuel Element for Nuclear Reactors	C. H. Bassett, Riverdale, Md.
[illegible] 989	Broaching and Tube-Installing Apparatus	C .E. Frantz, W. E. Cawley, Richland, Wash.
[illegible] 613	Fuel Element for Nuclear Reactors	C. H. Bassett, Riverdale, Md.
[illegible] 744	Means for Visualizing Fluid Flow Patterns	F. E. Lynch, Oak Ridge, Tenn.; L. D. Palmer; Leucadia, Calif.; H. F. Poppendiek, LaJolla, Calif.; G. M. Winn, Concord, Tenn.
[illegible] 833	Super-Regenerative Radio Ranging Device	R. T. Nieset, New Orleans, La.; H. R. Crane, Ann Arbor, Mich.; A. C. Gratian, J. W. Gratian, Rochester, N.Y.
[illegible] 995	Modified Ball and Socket Coupling	D. D. Kalem, Lynchburgh, Va.
[illegible] 505	Salt Conversion Process	H. H. Van Tuyl, Richland, Wash.
[illegible] 574	Overall Control System for High Flux Pile	H. W. Newson, Durham, N.C.; E. P. Wigner, Princeton, N.J.; E. P. Epler; T. E. Cole, Oak Ridge, Tenn.
[illegible] 824	Nondestructive Eddy Current Testing	C. J. Ranken, Jr., Lemont, Ill.
[illegible] 508	Neutronic Reactor Structure	A. M. Weinberg, Oak Ridge, Tenn.; H. C. Vernon, Wilmington, Del.
[illegible] 509	Fuel Element for Nuclear Reactor	J. G. Duffy, Jr., Ossining, N.Y.
[illegible] 510	Massive Leakage Irradiator	E. P. Wigner, Princeton, L. Szilard, Chicago, Ill.; R. F. Christy, Sante Fe, N. Mex.; F. L. Friedman, Chicago, Ill.
[illegible] 772	Eccentric Rolling of Powder and Bonding Agent into Spherical Pellets.	G. Patton, Jr., Lindenhurst, N.J.
[illegible] 375	Purification of Fluoride Salts	W. R. Grimes, Oak Ridge, Tenn.
[illegible] 454	Electrolytic Process for Producing Metals	B. Kopelman, Sands Point; and R. B. Holden, Bayside, N.Y.
[illegible] 455	Method and apparatus for Reactor Safety Control.	N. E. Huston, Woodland, Calif.; R. G. Hoff, C. W. Z. Wheelock, Canoga Park, Calif.
[illegible] 458	Twisted Ribbon Fuel Element	C. R. Breden, La Grange, Ill.; A. B. Schultz, Western Springs, Ill.
[illegible] 816	Bonding Aluminum Metals	R. A. Noland, Chicago; D. E. Waler, Park Forest, Ill.
[illegible] 429	Spiral Contractor for Solvent Extraction Column.	C. R. Cooley, Richland, Wash.
[illegible] 697	Linear Selsyn or Syncro-transmitter	A. Hirsch, Evergreen Park, Ill.
[illegible] 812	Method of Fabricating Tubular Units	L. S. Ohlinger, Los Angeles, Calif.
[illegible] 938	Control for Rolling Mill	A. B. Shuck, Wheaton, Ill.; W. C. Shaw, Joliet, Ill.
[illegible] 367	Arsenate Carrier Precipitation Method of Separating Plutonium from Neutron Irradiated Uranium and Radioactive Fission Products.	S. G. Thompson, D. R. Miller, R. A. James, Richmond, Calif.
[illegible] 368	Cesium Recovery From Aqueous Solutions	R. A. Schneider, Richland, Wash.
[illegible] 453	Pressure System Control	W. H. Esselman, Pittsburgh; G. M. Kaplan, Bethel Park, Pa.
[illegible] 454	Nuclear Reactor	C. R. Breden, La Grange, Ill.; J. R. Dietrich, Clearwater, Fla.

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PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—continued

Patent No.	Title	Patentee
2,989,556	Method of Preparing Complexes of Plutonium with Diketones.	J. S. Dixon, J. J. Katz, E. F. Orlemann, Chicago, Ill.
2,990,240	Process for Segregating Uranium from Plutonium and Fission-Product Contamination.	C. V. Ellison, Oak Ridge, Tenn., and T. [illegible] Runion, Hamilton, Ohio
2,990,241	Improvement in Decontamination of Aqueous Acidic Solutions Containing Plutonium and Fission Product Values by Providing Cerous and/or Mercuric Ions Therein Prior to a Bismuth Phosphate Carrier Precipitation.	B. F. Faris, H. K. Strassel, Richland, Wash.
2,990,242	Extraction of Hexavalent Plutonium from Aqueous Acidic Solutions with Ethyl Sulfide.	G. T. Seaborg, Chicago, Ill.
2,990,243	Adsorption of Plutonium and/or Fission Products from Aqueous Solution.	R. H. Beaton, Richland, Wash.
2,990,244	Extraction of Thorium and Uranium Values from Acid Leach Liquors.	K. B. Brown, D. J. Crouse, Jr., Oak Ridge, Tenn.
2,990,245	Metathesis of Bismuth Phosphate Plutonium Carrier Precipitate with an Alkali.	I. Perlman, Berkeley, Calif.; S. G. Thompson, Richmond; B. B. Cunningham, Berkeley, Calif.
2,990,273	Uranium Recovery from Metallic Masses	P. Chiotti, Ames, Iowa.
2,990,274	Uranium-Titanium-Niobium Alloys	S. Greenberg, Chicago, Ill.
2,990,348	Method and Apparatus for Producing Power.	E. O. Wollan, Oak Ridge, Tenn.
2,990,349	Reactor	W. G. Roman, Whitehall, Pa.
2,990,351	Nuclear Reactor Element	M. C. Sanz, Los Angeles; C. N. Scully, Pasadena, Calif.
2,990,352	Metal Sheathed Bodies	H. M. Finniston, L. M. Wyatt, O. S. Pall, London, England.
2,990,353	Nuclear Reactor Control System	D. F. Howard, E. E. Motta, Long Beach, Calif.
2,990,354	Nuclear Fission Chain Reacting System	H. L. Anderson, Chicago, Ill.; H. S. Brown, Oak Ridge, Tenn.
2,990,355	Means for Controlling Reactions	L. W. Nordheim, Oak Ridge, Tenn.; E. P. Wigner, Chicago, Ill.
2,990,356	Control Rod Drive	R. A. Chapellier, Whitestone, N.Y., and [illegible] Rogers, Cliffside Park, N.J.
2,990,357	Method and Apparatus for Controlling Neutron Density.	E. P. Wigner, Princeton, N.J., G. J. Young, Chicago, Ill.
2,990,358	Control Means for Reactor	J. H. Manley, Los Alamos, N. Mex.
2,990,359	Fuel Element Support	W. L. Wyman, Richland, Wash.
2,990,360	Neutronic Reactor Control Rod and Method of Fabrication.	S. W. Porembka, Jr., Pittsburgh, Pa.
2,990,476	Radiation Source	J. D. Gow, Berkeley, Calif.
2,991,112	Self-Centering Positive Locking Grapnel	C. G. Hopper, Hayward, Calif.
2,991,150	Purification of Plutonium Using a Cerium Precipitate as a Carrier for Fission Products.	B. F. Faris, Richland, Wash., C. M. Olsen, Newark, Del.
2,991,192	Process of Coating Graphite with Niobium-Titanium Carbide.	F. A. Halden, Sunnyvale; W. D. Smiley, Palo Alto; F. M. Hruz, Los Altos, Calif.
2,991,236	Separating Liquid Moderator from a Slurry Type Reactor.	H. C. Vernon, Oak Ridge, Tenn.
2,991,237	Thorium Dispersion in Bismuth	J. S. Bryner, Eastport, N.Y.
2,991,238	Pinched Plasma Reactor	J. A. Phillips, B. R. Suydam, J. L. Tuck, Los Alamos, N. Mex.
2,991,601	Process of Forming Powdered Material	J. Glatter, B. E. Schaner, T. J. Burke, Pittsburgh, Pa.
2,991,905	Gas Seal	H. Monson, Elmhurst; E. Hutter, Chicago, Ill.
2,991,980	Heat Transfer Means	A. P. Fraas, Knoxville, Tenn.; G. F. Wislicenus, State College, Pa.

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PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—continued

Patent No.	Title	Patentee
048	Tool Assembly with Bi-Directional Bearing	G. E. Longhurst, Watervliet, N.Y.
066	Preparation of Plutonium Trifluoride	L. L. Burger, W. E. Roake, Richland, Wash.
067	Dissolution of Zirconium and Alloys Thereof	J. L. Swanson, Richland, Wash.
172	Fuel Elements for Nuclear Reactors	A. Blainey, H. Lloyd, Strand, London, England.
175	Neutronic Reactor Shielding	L. B. Borst, Oak Ridge, Tenn.
178	High Strength Control Rods for Neutronic Reactors.	B. Lustman, E. F. Losco, I. Cohen, Pittsburgh, Pa.
179	Fuel Element for Nuclear Reactors	C. H. Bassett, Riverdale, Md.
249	Ion Exchange Adsorption Process for Plutonium Separation.	G. E. Boyd, Oak Ridge, Tenn.; E. R. Russell, Columbia, S.C.; M. D. Taylor, Washington. D.C.
700	Electrostatic Air Cleaning Device and Method.	L. Silvermann, Dover, Mass., D. M. Anderson, Cincinnati, Ohio.
786	Hot Pressing to Form Canned Uranium Slugs.	S. B. Roboff, White Plains; W. E. Kingston, Bayside, N.Y.
886	Method for Dissolving Zirconium-Uranium Compositions.	T. A. Gens, Oak Ridge, Tenn.
887	Leaching of Uranium Ores Using Alkaline Carbonates and Bicarbonates at Atmospheric Pressure.	A. Thunaes, E. A. Brown, A. T. Rabbitts, R. Simard, and H. J. Herbst, Ottawa, Canada.
888	Process of Treating or Forming an Insoluble Plutonium Precipitate in the Presence of an Organic Surface Active Agent.	J. H. Balthis, Wilmington, Del.
889	Method for Separating Plutonium and Fission Products Employing an Oxide as a Carrier for Fission Products.	T. H. Davies, Oak Ridge, Tenn.
915	Pyrometallurgical Method	P. A. Nelson, Wheaton, Ill.
981	Neutronic Reactor Core	W. B. Thomson, A. Corbin, Jr., Cincinnati, Ohio.
982	Coupled Fast-Thermal Power Breeder Reactor.	R. Avery, Elmhurst, Ill.
550	Fast Neutron Reactor	H. Soodak, Cambridge, Mass.; E. P. Wigner, Princeton, N.J.
551	High Temperature and Neutron Producing System.	G. P. Thomson, Cambridge, England; M. Blackman, London, England.
552	Neutronic Reactor	R. F. Christy, Pasadena, Calif.
919	Integral Positioning and Indicating Device	C. E. Frantz, W. E. Cawley, R. R. Warnick, Richland, Wash.
538	Electrical Load Anticipator and Recorder	J. B. Russell, Riverdale, Calif.; R. J. Thomas, Paducah, Ky.
072	Photoelectric Control for Tape Positioning	J. W. Woody, Jr., Oak Ridge, Tenn.
423	Apparatus for Sheathing Rods	G. W. Kinvig Ford, L. M. Wyatt, O. S. Plail, Strand, London, England.
577	Method of Removing Iodine from Gases and Filter Medium Therefor.	L. Silverman, Dover, Mass.
579	Dissolution of a Cerium-Type Plutonium-Containing Fluoride Carrier.	Arthur C. Wahl, University City, Mo.
650	Preparation of Pure Metals from Their Compounds.	H. L. Slatin, New York, N.Y.,
652	Method for Producing Diboron Tetrachloride	J. W. Frazer, Livermore, Calif.; R. T. Holzmann, Sparta, N.J.
656	Fuel Element Construction	L. R. Zumwalt, La Jolla, Calif.
657	Chimney for Boiling Water Reactor	M. Petrick, Hammond, Ind.
687	Adjustable Double Pulse Generator	J. W. Gratian, A. C. Gratian, Rochester, N.Y.
651	Method of Applying Metallic Coatings	J. W. Robinson, Brecksville, Ohio; L. D. Eubank, South Euclid, Ohio.
419	Method for Dissolving Lanthanum Fluoride Carrier for Plutonium.	D. E. Koshland, Jr., Cambridge, Mass.; J. F. Willard, Madison, Wis.
471	Method for Treating Graphite Product	D. H. Gurinsky, Rancho Santa Fe, Calif.

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PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—continued

Patent No.	Title	Patentee
2,995,588	Extraction of Tetravalent Plutonium Values with Methyl Ethyl Ketone, Methyl Isobutyl Ketone, Acetophenone or Menthone.	G. T. Seaborg, Washington, D.C.
2,995,925	Ultrasonic Flaw Detection Method and Means.	D. C. Worlton, San Jose, Calif.
2,996,330	Remotely Operated Manipulator	E. L. Hutto, Oak Ridge, Tenn.
2,996,352	Precipitation of Plutonous Peroxide	J. G. Barrick, Cleveland, Ohio; J. P. Manion, New Haven, Conn.
2,996,375	Process of Recovering Alkali Metals	J. Wolkoff, Park Forest, Ill.
2,996,443	Fissile Material and Fuel Elements for Neutronic Reactors.	B. E. Schaner, Mount Lebanon, Pa.,
2,996,444	Fuel Element Construction	M. T. Simnad, La Jolla, Calif.
2,996,526	Extraction of Tetravalent Plutonium Values from Aqueous Acid Solutions by 2(B-Ethylbutoxy) Ethanol.	G. T. Seaborg, Washington, D.C.
2,996,662	Magnetic Densitometer	J. A. McCann, R. H. Jones, Scotia, N.Y.
2,997,289	Apparatus for the Production of Lithium Metal.	P. S. Baker, F. R. Duncan, H. B. Gr[illegible], Oak Ridge, Tenn.
2,997,431	Method of Initiating and Sustaining an Energetic Plasma for Neutron Production.	P. R. Bell, Robert J. Mackin, Jr., A. S[illegible], Oak Ridge, Tenn.
2,997,436	Gas Ionizing and Compressing Device	E. M. Little and D. B. Thomson, Los Alamos, N. Mex.; V. Josephson, Palos Verdes Estates, R. S. Franklin, San Diego, Calif.
2,997,587	Neutronic Reactor Core Instrument	L. S. Mims, Tarzana, Calif.
2,997,641	Plasma Generator Device	W. R. Baker, Orinda; O. A. Anderson, Oakland; H. P. Furth, Berkeley, Calif.
2,997,744	Method of Graphite Preparation	S. D. Stoddard, Los Alamos, N. Mex.; W. T. Harper, Indian Village, Ga.
2,997,883	Acceleration Integrating Means	D. F. Wilkes, Albuquerque, N. Mex.
2,998,917	Electrical Load Anticipator and Recorder	J. V. Werme, Painesville, Ohio.
2,999,059	Nuclear Reactor	M. Treshow, Downers Grove, Ill.
2,999,060	Control Means for a Nuclear Reactor	R. J. Teitel, Midland, Mich.
2,999,168	Linear Count-Rate Meter	J. J. Henry, Oak Ridge, Tenn.
2,999,187	Differential Fault Sensing Circuit	J. H. Roberts, Erlton, N.J.
3,000,377	Method and Apparatus for Metabolic Assay	B. M. Tolbert, Berkeley; M. R. Kirk, Concord; E. M. Baker, Berkeley, Calif.
3,000,695	Compounds and Compositions Containing Plutonium.	G. T. Seaborg, Washington, D.C.
3,000,697	Transuranic Element, Composition Thereof, and Methods for Producing, Separating and Purifying Same.	A. C. Wahl, Santa Fe, N. Mex.
3,000,726	Production of Metals	F. H. Spedding, H. A. Wilhelm, W. H. Keller, Ames, Iowa.
3,001,144	Direct Coupled Amplifier for Small Currents.	R. A. Dandl, Oak Ridge, Tenn.
3,001,238	Method of Making Metal Bonded Carbon Bodies.	W. V. Goeddel, San Diego; M. T. Simnad, La Jolla, Calif.
3,001,847	Optical Transcribing Oscilloscope	Q. A. Kerns, Orinda, Calif.
3,002,095	Single-Crystal Neutron Spectrometer	D. L. Holcomb, Powell, Tenn.
3,002,852	Method of Forming Tantalum Silicides on Tantalum Surfaces.	M. G. Bowman, N. H. Krikorian, Los Alamos, N. Mex.
3,002,910	Catalytic Conversion of Organic Compounds Using Penetrating Radiation.	J. M. Caffrey, Jr., Beacon, N.Y.
3,002,911	Radiolysis of Organic Compounds in the Adsorbed State.	J. W. Sutherland, Upton; A. O. Allen, Stony Brook, N.Y.
3,002,912	Reactors	L. Spitzer, Jr., Princeton, N.J.
3,003,002	Purification of Ether	R. N. Feinstein, Downers Grove, Ill.
3,003,050	Welding Torch	T. B. Correy, Richland, Wash.
3,003,080	Apparatus for Minimizing Energy Losses from Magnetically Confined Volumes of Hot Plasma.	R. F. Post, Walnut Creek, Calif.

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PATENTS ISSUE

Patent No.	
1,004,628	Rectified Adsorp tion of Hydrog
1,004,823	Method of Separ Liquid Extrac
1,005,079	A Method and Thermal Bond
1,005,158	Core Saturation
1,005,334	Apparatus for N Cantilevered M
1,005,680	Method of Separ
1,005,681	Separation Proce
1,005,682	Method of Dissol Nitric Acid Us
1,005,683	Separation of Tec lutions by Copr
1,005,760	Method of Oppos cosity Increase Fluids.
1,005,764	Neutronic Reacto
1,005,765	Density Control i
1,005,767	Rotating Plasma
1,005,794	Method of Using Equivalent to C
1,005,931	Ion Gun
1,005,950	A Precision Inte Currents.
1,006,954	Apparatus for Cor erators.
1,006,835	Neutron Source Us of Plasma.
1,006,859	Processing of Radi
1,006,884	Process for Ma Bodies.
1,006,904	Processing of Radi
1,006,062	Absorption Analy
1,006,242	Zirconium-Claddin
1,006,767	Separation of Tra Rare Earth Com
1,006,768	Continuous Proces Hexafluoride fro and Oxygen.
1,006,807	Yttrium Decontam
1,006,866	Neutronic Reactor.
1,006,021	Method for Measur

PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING—Continued

Patent No.	Title	Patentee
[illegible]	Rectified Adsorption Method for the Separation of Hydrogen Isotopes.	D. N. Hanson, San Francisco, Calif.; C. d'A Hunt, Orinda, Calif.
[illegible]	Method of Separating Neptunium by Liquid-Liquid Extraction.	D. F. Peppard, Oak Park, Ill.; G. W. Mason Clarendon Hill, Ill.
[illegible]	A Method and Apparatus for Effecting Thermal Bonds.	H. O. Monson, Elmhurst, Ill.; R. A. Jaross, Downers Grove, Ill.
[illegible]	Core Saturation Blocking Oscillator	R. J. Spinrad, Cambridge, Mass.
[illegible]	Apparatus for Non-Destructive Inspection of Cantilevered Members.	E. R. Taylor, Knoxville, Tenn.; C. H. Mahoney, Oak Ridge, Tenn.; C. R. Lay, Kingston, Tenn.
[illegible]	Method of Separating Neptunium	G. T. Seaborg, Washington, D.C.
[illegible]	Separation Process	R. W. Stoughton, Oak Ridge, Tenn.
[illegible]	Method of Dissolving Plutonium Dioxide in Nitric Acid Using Cerium Ions.	A. S. Wilson, Richland, Wash.
[illegible]	Separation of Technetium from Aqueous Solutions by Coprecipitation with Magnetite.	S. J. Rimshaw, Loudon, Tenn.
[illegible]	Method of Opposing irradiation-induced Viscosity Increase in Employment of Organic Fluids.	R.O. Bolt, San Rafael, Calif.
[illegible]	Neutronic Reactor Structure	F. Daniels, Madison, Wis.
[illegible]	Density Control in a Reactor	J. Marshall, Jr., Chicago, Ill.
[illegible]	Rotating Plasma Device	K. Boyer, J. E. Hammel, C. L. Longmire, D. E. Nagle, F. L. Ribe, J. L. Tuck, Los Alamos, N. Mex.
[illegible]	Method of Using and Manufacturing Plastic Equivalent to Organic Materials.	F. R. Shonka, Riverside, Ill.; J. E. Rose, Elmhurst, Ill.; G. Failla, deceased.
[illegible]	Ion Gun	R. A. Dandl, Oak Ridge, Tenn.
[illegible]	A Precision Integrator for Minute Electric Currents.	R. J. Helmer, A. Hemmendinger, Los Alamos, N. Mex.
[illegible]	Apparatus for Control of High Energy Accelerators.	H. G. Heard, Berkeley, Calif.
[illegible]	Neutron Source Using Magnetic Compression of Plasma.	W. E. Quinn, Los Alamos, New Mex.; W. C. Elmore, Swathmore, Penn.; E. M. Little, K. Boyer, J. L. Tuck, Los Alamos, N. Mex.
[illegible]	Processing of Radioactive Waste	R. T. Allemann, Richland, B. M. Johnson, Jr., Kennewick, Washington.
[illegible]	Process for Making Neutron-Absorbing Bodies.	G. H. Schippereit, Columbus, Ohio; M. Lang, Torrance, Calif.
[illegible]	Processing of Radioactive Waste	B. M. Johnson, Jr., B. Barton, Kennewick, Wash.
[illegible]	Absorption Analyzer	W. A. Brooksbank, Jr., Oak Ridge, Tenn.; G. W. Leddicotte, Knoxville, Tenn.; J. E. Strain and H. H. Hendon, Jr., Las Vegas, Nev. and San Jose, Calif.
[illegible]	Zirconium-Cladding of Thorium	R. J. Beaver, Knoxville, Tenn.
[illegible]	Separation of Transuranic Elements from Rare Earth Compounds.	T. P. Kohman, Chicago, Ill.
[illegible]	Continuous Process for Preparing Uranium Hexafluoride from Uranium Tetrafluoride and Oxygen.	J. B. Adams, J. C. Bressee, L. M. Ferris, Oak Ridge, Tenn.
[illegible]	Yttrium Decontamination	D. H. Dennison, Ames, Iowa
[illegible]	Neutronic Reactor	A. P. Fraas, Knoxville, Tenn.; C. B. Mills, Los Alamos, N. Mex.
[illegible]	Method for Measuring Radiation	W. C. Roesch, R. C. McCall, Richland, Wash.

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Foreign Patents Issued to the Commission Which Are Available for Licensing

The below-listed abstracts of Commission-owned foreign patents have been released during the past year. Inquiries with respect to licenses should be directed to the Assistant General Counsel for Patents.[1]

BELGIAN PATENTS

Patent No.	Title
551, 681	Fuel for Neutronic Reactors & Process of Making.
553, 216	Neutronic Reactor Control.
556, 027	Neutronic Reactor Control.
557, 511	Composite Element and Method of Manufacture.
558, 856	Organic Orthophosphate Extractants and Process.
559, 766	Neutronic Reactor.
559, 844	Fuel-Breeder Fuel Element for Nuclear Reactor.
559, 845	Fuel-Breeder Element for a Nuclear Reactor.
559, 906	Process for Separation of Protactinium, Thorium and Uranium from Neutron-Irradiated Thorium.
559, 907	Method and Apparatus for Reactor Safety Control.
560, 742	Method of Operating Nuclear Reactors.
561, 140	Uranium Recovery from Alloys.
561, 141	Plates with Oxide Inserts.
562, 247	Production of Uranium.
562, 779	Method of Handling Active Waste Solutions.
562, 991	Fluoride Volatility Process for the Recovery of Uranium.
563, 915	Uranium Recovery Process.
564, 258	Nuclear Reactor Including a Package Safety Device.
564, 399	Method of Preparing a Fuel Element for a Nuclear Reactor.
565, 765	Nuclear Reactor.
566, 326	Multistage Fluidized Bed Reactor.
566, 973	Nuclear Reactor Core Design.
567, 077	Method of Making Fuel Elements.
567, 113	Process of Making a Neutronic Reactor Fuel Element Composition.
567, 472	Boiling Water Reactor.
568, 229	Production of Purified Uranium.
569, 633	Direct Ingot Process for Producing Uranium.
569, 879	Preparation of High Purity UF_4.
570, 210	Steam Forming Neutronic Reactor and Method of Operating it.
570, 428	Chelating Agents and Process.
570, 983	Method of Suppressing U-Al_4 Formation in U-Al Alloys.
571, 133	Method of Bonding.
571, 474	Nuclear Reactor Fuel Element.
571, 603	High Energy Gaseous Discharge Devices.
571, 605	High Energy Gaseous Plasma Containment Device.
571, 708	Reactor.
571, 864	Electrolysis of Thorium and Uranium.
572, 172	Sintering Metal Oxides.
572, 280	Method of Preparing a Fuel Element.
572, 397	Production of High Purity Uranium Tetrafluoride.
572, 899	Powder Compact for Neutronic Reactor Fuel Elements.
573, 083	Power Breeder Reactor.
573, 384	Control Rod Alloy Containing Noble Metal Additions.
573, 385	Reactor.
573, 549	Fast Breeder Reactor.
574, 552	Method and Apparatus for Trapping Ions in a Magnetic Field.
575, 109	Nuclear Reactor Fuel Element.
575, 635	Nickel-Base Alloy.
575, 688	Method of Increasing the Dispersibility of Slurry Particles.
576, 023	Alloy Member and Process for Making the Same.
576, 718	Neutronic Reactor Fuel Element.
576, 844	Nuclear Superheater for Boiling Water Reactor.
576, 941	Compartmented Reactor Fuel Element.
576, 979	Nuclear Reactor.
576, 980	Gas-Cooled Neutronic Reactor.
576, 996	Method of Making UO_2-BI Slurries.
577, 222	Solid State Bonding of Thorium with Aluminum.
577, 223	Method for Producing High Strength Control Rods for Neutronic Reactors and Control Rods Produced Thereby.
577, 224	Extraction of Uranium.
577, 225	Method and Means for Electrolytic Purification of Plutonium.
577, 962	Thermonuclear Injection Process and Injector.
578, 090	Composite Fuel Element.
578, 382	High Temperature, High Power Heterogeneous Nuclear.
578, 428	Magnetic End Closures for Controlled Fusion Reactors.
579, 111	Control Means for a Nuclear Reactor.
579, 430	Uranium-Titanium-Niobium Alloys.
579, 501	Erythropoietic Factor Preparation.
579, 676	Regeneration of Reactor Fuel Elements.
580, 158	Apparatus and Method for Confining a Plasma.

[1] See footnote on p. 404.

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BELGIAN PATENTS—Con.

Patent No.	Title	Patent No.	Title
[illegible].379	Fused Salt Process for Recovery of Values from Used Nuclear Reactor Fuels.	589, 412	Dissolution of Zirconium Containing Fuel Elements.
[illegible].455	Plutonium-Cerium-Cobalt and Plutonium-Cerium-Nickle Alloys	589, 415	Fluidized Solids Process and Recovery of Uranium from Zirconium-Type Fuel Element.
[illegible].055	Neutronic Reactor Fuel Element and Method for Making Same.	589, 473	Neutronic Reactor Control Rod and Method of Fabrication.
[illegible].270	Thermonuclear Reactor.	589, 678	Uranium Base Alloy.
[illegible].428	Reactor Control.	589, 679	Nuclear Reactor.
[illegible].473	Fuel Element.	590, 461	High Temperature Reduction of Uranium Hexafluoride to Metal.
[illegible].733	Calandria Type Sodium Graphite Reactor.	590, 829	Fuel Element.
[illegible].391	Method for coating Graphite with Niobium Carbide.	591, 154	Eccentric Rolling of Powder and Bonding Agent into Spherical Pellets.
[illegible].392	Brazing Alloy.	591, 155	Fused Reactor Fuels.
[illegible].181	Thermoelectric Cell and Reactor.	591, 451	Plutonium Alloys Containing Controlled Amounts of Plutonium Allotropes Obtained of High Pressures.
[illegible].312	Heat Transfer Device.	592, 873	Salt Conversion Process.
[illegible].062	Boiling Water Reactor.	592, 930	Neutronic Reactor Control Element.
[illegible].227	Method of Reducing Aqueous Radioactive Nuclear Wastes to Solid Form.	593, 149	Method of Joining Carbides to Base Metals.
[illegible].079	Nuclear Fuel Material.	594, 354	Fuel Element.
[illegible].167	Method of Making Fuel Bodies.	594, 584	Method of Reprocessing UO_2 Reactor Fuel.
[illegible].168	Fuel Element Construction.	595, 635	Braze Bonding of Columbium.
[illegible].320	Concentric Tubular Fuel Element.	595, 901	Sodium Deuterium Reactor.
[illegible].510	Plutonium Extraction Process.	595, 989	Improved Method for Pumping Gases at Low Vacuum Pressures.
[illegible].969	Merchant Marine Ship Reactor.	597, 033	Method for Dissolving Zirconium Uranium Composition.
[illegible].974	Improved Process for the Preparation of Uranium Tetrafluoride From Uranium Dioxide.	597, 504	Tube Splitting Apparatus.
[illegible].917	Fuel Element for a Nuclear Reactor.	597, 666	Coupler for Tool and Cable.
[illegible].160	Catalyst.	597, 711	Improved Chimney for Boiling Water Reactor.
[illegible].872	Ultrasonic Neutron Dosimeter.	598, 364	Area Radiation Monitor.
[illegible].141	A Method of Preparing Fuel Elements for Nuclear Reactors.		
[illegible].717	Nuclear Propelled Vehicle.		
[illegible].349	Moderator Elements for Uniform Power Nuclear Reactor.		

BRITISH PATENTS

[illegible].945	Electromagnetic Apparatus for Moving a Rod.	828, 352	Neutronic Reactor Control.
		829, 427	Neutronic Reactor Control.
[illegible].817	Fuel-Breeder Fuel Element for Nuclear Reactor.	829, 661	Nuclear Reactor.
		830, 937	Method of Isotope Concentration.
[illegible].980	Uranium-Oxide-Containing Fuel Element.	832, 959	Control Rod Alloy Containing Noble Metal Additions.
[illegible].408	Production of Uranium.	833, 153	Production of Purified Uranium.
[illegible].526	Nuclear Reactor Component Cladding Material.	834, 244	Remote-Control Manipulator.
		834, 360	Uranium Recovery Process.
[illegible].590	Uranium from Ores with Hydrochloric.	834, 663	Electronic Master Slave Manipulator.
[illegible].515	Remote ControlManipulator.	834, 701	Method of Operating Nuclear Reactors.
[illegible].516	Remote Control Manipulator.	836, 745	Multiple Spark Gap Switch.
[illegible].164	Electromagnetic Apparatus for Moving a Rod.	836, 843	Neutronic Reactor.
		837, 769	A Neutronic Reactor.
[illegible].744	Plasma Generator.	837, 930	Method of Making Fuel Elements.
[illegible].672	Method and Apparatus for Reactor Safety Control.	837, 967	Method of Handling Active Waste Solutions.
[illegible].579	Uranium Recovery from Alloys.	838, 324	Process of Producing Jacketed Bodies.
[illegible].100	Recovery of Uranium from Low Grade Uranium Bearing Ores.	840, 017	High Energy Gaseous Discharge Devices.
[illegible].085	Neutronic Reactor System.	840, 136	Ternary Alloy-Containing Plutonium.

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BRITISH PATENTS—Continued

Patent No.	Title
840, 203	Method of Protecting Tantalum Crucibles Against Reaction with Molten Uranium.
840, 740	Steam Stirred Homogeneous Nuclear Reactor.
840, 753	Plates with Oxide Inserts.
840, 789	Boiling Water Reactor.
841, 608	Method of Preparing a Fuel Element.
841, 792	Thermonuclear Reactor.
842, 500	Continuous Process for the Conversion of UF_6 to UF_4.
843, 307	Plutonium-Uranium-Titanium Alloys.
843, 636	Method and Apparatus for Improving Performance of a Fast Reactor.
843, 648	Ion Source.
844, 291	Reactor.
844, 711	Nuclear Reactor.
844, 833	Method of Making UO_2-BI Slurries.
845, 655	Multistage Fluidized Bed Reactor.
846, 433	Plutonium-Cerium Alloy.
847, 013	Process of Making a Neutronic Reactor Fuel Element Composition.
847, 843	Engineering Test Reactor.
847, 847	Fuel-Breeder Element for a Nuclear Reactor.
848, 609	Sintering Metal Oxides.
849, 208	High Energy Gaseous Plasma Containment Device.
849, 713	Plutonium-Uranium Alloy.
849, 716	Spring Driven Actuating Mechanism.
850, 945	Accelerometer.
851, 925	Coaxial Control Rod Drive Mechanism for Neutronic Reactors.
851, 983	Method of Increasing the Dispersibility of Slurry Particles.
852, 366	Nuclear Reactor Including a Package Safety Device.
852, 979	Preparation of High Density UO_2.
853, 394	Method of Preparing a Fuel Element.
853, 916	Method and Apparatus for Trapping Ions in a Magnetic Field.
854, 096	Alloy Member and Process for Making the Same.
854, 808	Uranium-Titanium-Niobium Alloys.
854, 869	Method and Means of Producing High Density Plasmas.
855, 490	Regeneration of Reactor Fuel Elements.
855, 671	Push-Pull Power Reactor.
855, 811	Volatile Chloride Process for the Recovery of Metal Values.
856, 221	Method for Joining Aluminum to Stainless Steel.
857, 672	Method of Preparing a Fuel Element for a Nuclear Reactor.
857, 883	Stabilized Pinch Machine.
857, 959	Power Breeder Reactor.
858, 061	Composite Element and Method of Manufacture.
858, 734	Device and Method for Producing a High Intensity Arc Discharge.
859, 122	Forming Protective Films on Metal.
859, 356	High Temperature, High Power Heterogeneous Nuclear.
859, 459	Apparatus and Method for Confining a Plasma.
859, 548	Control Rod.
860, 141	Direct Ingot Process for Producing Uranium.
860, 161	Plutonium Alloys.
860, 840	Pyrotron with Translational Cleaning Fields.
861, 191	Preparation of Uranium Trioxide.
861, 700	Regeneration of Reactor Fuel Elements.
862, 204	Organic Orthophosphate Extractants and Process.
862, 464	Compartmented Reactor Fuel Elements.
862, 835	Arc Discharge and Method of Producing the Same.
862, 860	Electrolysis of Thorium and Uranium.
862, 900	Continuous Plasma Generator.
865, 011	Process for Separation of Protactinium, Thorium and Uranium from Neutron-Irradiated Thorium.
865, 029	Thorium Dispersion in Bismuth.
865, 082	Thermonuclear Injection Process and Injector.
865, 095	Uranium Recovery Process.
865, 729	Catalytic Recombination of Radiolytic Gases in Thorium Oxide Slurries.
865, 737	Method and Means for Electrolytic Purification of Plutonium.
865, 778	Processing of Neutron-Irradiated Uranium.

CANADIAN PATENTS

553, 573	Process for Continuously Separating Irradiation Products of Thorium.
563, 411	Uranium Recovery from Ores with Hydrochloric.
563, 428	Remote Control Manipulator.
563, 429	Liquid Metal Compositions Containing Uranium.
563, 430	Uranium Bismuthide Dispersion in Molten Metal.
563, 431	Method of Separating Fission Products from Fused Bismuth-Containing Uranium.
563, 432	Formation of Intermetallic Compound Dispersions.
563, 435	Method of Purifying Liquid Fuels of Nuclear Reactors.
563, 440	Method of Isotope Concentration.
572, 166	Process for Removal of Rare Earths from Uranyl Sulfate Solutions.
572, 170	Recovery of Uranium from Low Grade Uranium Bearing Ores.
572, 171	Volatile Chloride Process for the Recovery of Metal Values.

Patent No.	Ti
172	Uranium-Oxide-Con ment.
181	Pyrochemical Decont for Reactor Fuel.
182	Uranium Recovery f
926	Production of Uranit
936	Uranium Recovery I
160	Ion Source.
170	Method of Handli Solutions.
173	Process of Recovery Its Ores.
174	Recovery of Uraniun
482	Power Generation fr Nuclear Fuel.
214	Fuel For Neutronic I of Making.
065	Accelerometer.
122	Pyrochemical Proc Scavenging.
131	Plutonium-Cerium A
948	Neutronic Reactor C
014	Improved Preparatio Thorium-Uranium
015	Method of Purifying
326	Remote-Control Man
331	Inhibition of Corrosic
333	Electronic Master Sl
335	Remote Control Man
357	Nuclear Reactor Cor Material.
372	Electromagnetic App a Rod.
375	Neutronic Reactor C
379	Method and Apparat Performance of a Fa
404	Fuel-Breeder Elemen actor.
405	Fuel-Breeder Fuel El Reactor.
408	Control Rod.
432	Multistage Fluidized
434	Ternary Alloy-Conta
435	Process of Making a N Fuel Element Com
538	Electronic Master Slav
880	Neutronic Reactor Co
488	Uranium Recovery fr drochloric.
800	Neutronic Reactor Co
772	Composite Element Manufacture.
875	Neutronic Reactor.
800	Uranium Recovery fro
905	Plates with Oxide Ins
732	Method of Operating
560	Nuclear Reactor.

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CANADIAN PATENTS—Continued

Patent No.	Title	Patent No.	Title
[illegible]	Uranium-Oxide-Containing Fuel Element.	591, 437	Production of Purified Uranium.
[illegible]	Pyrochemical Decontamination Method for Reactor Fuel.	591, 450	Plutonium-Thorium Alloys.
[illegible]	Uranium Recovery from Alloys.	591, 453	Sintering Metal Oxides.
[illegible]	Production of Uranium.	591, 458	Method of Making UO_2-BI Slurries.
[illegible]	Uranium Recovery Process.	599, 076	Push-Pull Power Reactor.
[illegible]	Ion Source.	599, 173	Direct Ingot Process for Producing Uranium.
[illegible]	Method of Handling Active Waste Solutions.	599, 180	Superconducting Vanadium Base Alloy.
[illegible]	Process of Recoverying Uranium from Its Ores.	599, 181	Separation of Plutonium from Uranium.
[illegible]	Recovery of Uranium Values.	601, 524	Forming Protective Films on Metal.
[illegible]	Power Generation from Liquid Metal Nuclear Fuel.	601, 586	Method of Operating Nuclear Reactors.
[illegible]	Fuel For Neutronic Reactors & Process of Making.	601, 618	Nuclear Reactor Including a Package Safety Device.
[illegible]	Accelerometer.	601, 654	Plutonium-Uranium Alloy.
[illegible]	Pyrochemical Processing by Solid Scavenging.	601, 655	Plutonium-Uranium Alloy.
[illegible]	Plutonium-Cerium Alloy.	601, 685	Plutonium-Zirconium Alloys.
[illegible]	Neutronic Reactor Control.	601, 708	Method of Increasing the Dispersibility of Slurry Particles.
[illegible]	Improved Preparation of Thorium and Thorium-Uranium Oxides.	604, 269	Electromagnetic Apparatus for Moving a Rod.
[illegible]	Method of Purifying Uranium Metal.	604, 320	Plasma Generator.
[illegible]	Remote-Control Manipulator.	604, 411	Coaxial Control Rod Drive Mechanism for Neutronic Reactors.
[illegible]	Inhibition of Corrosion.	604, 453	Nuclear Reactor Fuel Element.
[illegible]	Electronic Master Slave Manipulator.	604, 756	Engineering Test Reactor.
[illegible]	Remote Control Manipulator.	604, 773	Method and Apparatus for Reactor Safety Control.
[illegible]	Nuclear Reactor Component Cladding Material.	604, 781	Plates with Oxide Inserts.
[illegible]	Electromagnetic Apparatus for Moving a Rod.	604, 814	Method of Preparing a Fuel Element for a Nuclear Reactor.
[illegible]	Neutronic Reactor Control.	604, 829	Nuclear Reactor.
[illegible]	Method and Apparatus for Improving Performance of a Fast Reactor.	604, 856	Separation of Metal Salts by Adsorption.
[illegible]	Fuel-Breeder Element for a Nuclear Reactor.	604, 858	Catalytic Recombination of Radiolytic Gases in Thorium Oxide.
[illegible]	Fuel-Breeder Fuel Element for Nuclear Reactor.	604, 870	Preparation of High Density UO_2.
[illegible]	Control Rod.	608, 860	Method and Apparatus for Calcining Salt Solutions.
[illegible]	Multistage Fluidized Bed Reactor.	609, 780	Acidic Aqueous Homogeneous Fission Reactor Fuels.
[illegible]	Ternary Alloy-Containing Plutonium.	610, 171	Electrolysis of Thorium and Uranium.
[illegible]	Process of Making a Neutronic Reactor Fuel Element Compositions.	610, 172	Reactor Fuel Scavenging Means.
		610, 178	Neutronic Reactor Fuel Compositions.
		610, 220	Method for Purifying Uranium.
		610, 225	Single-Step Conversion of UO_2 to UF_4.

FRENCH PATENTS

[illegible]	Electronic Master Slave Manipulator.	1, 186, 273	Fuel-Breeder Fuel Element for Nuclear Reactor.
[illegible]	Neutronic Reactor Control.	1, 186, 274	Fuel-Breeder Element for a Nuclear Reactor.
[illegible]	Uranium Recovery from Ores with Hydrochloric.	1, 188, 033	Method of Handling Active Waste Solutions.
[illegible]	Neutronic Reactor Control.	1, 188, 048	Fluoride Volatility Process for the Recovery of Uranium.
[illegible]	Composite Element and Method of Manufacture.	1, 188, 528	Process for Separation of Protactinium, Thorium and Uranium from Neutron-Irradiated Thorium.
[illegible]	Neutronic Reactor.	1, 188, 560	Production of Uranium.
[illegible]	Uranium Recovery from Alloys.		
[illegible]	Plates with Oxide Inserts.		
[illegible]	Method of Operating Nuclear Reactors.		
[illegible]	Nuclear Reactor.		

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FRENCH PATENTS—Continued

Patent No.	Title
1,192,201	Method and Apparatus for Reactor Safety Control.
1,193,653	Organic Orthophosphate Extractants and Process.
1,195,024	Process of Making a Neutronic Reactor Fuel Element Compositions.
1,195,622	Boiling Water Reactor.
1,197,752	Uranium Recovery Process.
1,197,868	Nuclear Reactor Including a Package Safety Device.
1,198,569	Method of Preparing a Fuel Element for a Nuclear Reactor.
1,198,928	Catalyzed Oxidation of Uranium in Carbonate Solutions.
1,203,418	High Energy Gaseous Plasma Containment Device.
1,203,419	High Energy Gaseous Discharge Devices.
1,204,910	Sintering Metal Oxides.
1,205,890	Nuclear Reactor
1,206,698	Nuclear Reactor Core Design.
1,207,845	Direct Ingot Process for Producing Uranium.
1,207,874	Preparation of High Purity UF_4.
1,207,935	Steam Forming Neutronic Reactor and Method of Operating it.
1,208,454	Pressure System Control.
1,208,840	Control Rod Alloy Containing Noble Metal Additions.
1,209,566	Chelating Agents and Process.
1,210,887	Method of Suppressing UAl_4 Formation in U–Al Alloys.
1,210,904	Method of Bonding.
1,212,243	Nuclear Reactor Fuel Element.
1,212,290	Reactor.
1,212,348	Electrolysis of Thorium and Uranium.
1,212,737	Method of Making Fuel Elements.
1,215,190	Powder Compact for Neutronic Reactor Fuel Elements.
1,215,419	Fast Breeder Reactor.
1,217,372	Method of Increasing the Dispersibility of Slurry Particles.
1,218,000	Reactor.
1,218,950	Nuclear Superheater for Boiling Water Reactor.
1,219,081	Method of Making UO_2-BI Slurries.
1,220,414	Neutronic Reactor Fuel Element.
1,220,753	Pinch Device.
1,221,160	Alloy Members and Process for Making the Same.
1,221,425	Solid State Bonding of Thorium with Aluminum.
1,221,426	Extraction of Uranium.
1,221,442	Method for Producing High Strength Control Rods for Neutronic Reactors and Control Rods Produced Thereby.
1,222,070	Method and Means for Electrolytic Purification of Plutonium.
1,222,257	Destruction of Neutral Particles in Thermonuclear Reactors.
1,222,604	Method and Apparatus for Trapping Ions in a Magnetic Field.
1,222,819	Nuclear Reactor Fuel Element.
1,222,922	Compartmented Reactor Fuel Element.
1,223,197	High Temperature, High Power Heterogeneous Nuclear.
1,223,198	Continuous Plasma Generator.
1,223,778	Magnetic End Closures for Controlled Fusion Reactors.
1,224,646	Rotating Plasma Thermonuclear Device.
1,224,647	Plasma Device.
1,225,418	Device and Method for Producing a High Intensity Arc Discharge.
1,226,062	Control Means for a Nuclear Reactor
1,226,385	Uranium-Titanium-Niobium Alloys
1,227,096	Regeneration of Reactor Fuel Elements.
1,228,647	Method for Purifying Uranium.
1,229,237	Fused Salt Process for Recovery of Values from Used Nuclear Reactor Fuels.
1,229,393	Intense Energetic Gas Discharge.
1,229,542	Method of Joining Aluminum to Stainless Steel.
1,229,765	Nickel-Base Alloy.
1,229,841	Nuclear Reactor.
1,229,842	Gas-Cooled Neutronic Reactor.
1,230,149	Apparatus and Method for Confining a Plasma.
1,230,661	Thermonuclear Injection Process and Injector.
1,230,671	Composite Fuel Element.
1,230,672	Pyrotron Process and Apparatus Utilizing Enhancement Principle.
1,230,972	Method and Apparatus for Producing Intense Energetic Gas Discharges.
1,231,554	Reactor Control.
1,231,660	Multistage Fluidized Bed Reactor.
1,233,199	Plutonium-Cerium-Cobalt and Plutonium-Cerium-Nickel Alloys.
1,233,784	Neutronic Reactor Fuel Element and Method for Making Same.
1,233,894	Thermonuclear Reactor.
1,234,411	Fuel Element.
1,234,529	Brazing Alloy.
1,234,873	Electron Gun.
1,234,901	Thermonuclear Reactor.
1,234,942	Method for Coating Graphite with Niobium Carbide.
1,236,953	Heat Transfer Device.
1,237,542	Boiling Water System.
1,237,764	Regeneration of Reactor Fuel Elements.
1,237,970	Calandria Type Sodium Graphite Reactor.
1,238,751	Method of Preparing a Fuel Element.
1,238,755	Power Breeder Reactor.
1,239,488	Thermoelectric Cell and Reactor
1,241,470	Plutonium Extraction Process.
1,243,365	Fuel Element Construction.
1,243,386	Method of Making Fuel Bodies.
1,243,616	Nuclear Fuel Material.
1,244,914	Improved Pinched Plasma Reactor.
1,245,550	Production of Purified Uranium.
1,245,565	Production of High Purity Uranium Tetrafluoride.

Patent No.	Title
[illegible]	Concentric Tub
[illegible]	Accelerometer.
[illegible]	Method of Red active Nuclear
[illegible]	Merchant Marin
[illegible]	Improved Proce Uranium Tetr Dioxide.
[illegible]	Catalyst.
[illegible]	Nuclear Propelle
[illegible]	Fuel Element fo
[illegible]	Moderator Elem Nuclear React
[illegible]	Ultrasonic Neut
[illegible]	Dissolution of Fuel Elements
[illegible]	Fluidized Solids of Uranium Fuel Element.
[illegible]	Electronic Maste
[illegible]	Neutronic React
[illegible]	Composite Ele Manufacture.
[illegible]	Method and A Safety Control
[illegible]	Method of Opera
[illegible]	Fluoride Volatil covery of Uran
[illegible]	Process for Sepa Thorium and U Irradiated Tho
[illegible]	Accelerometer.
[illegible]	Uranium Recove
[illegible]	Nuclear Reactor Safety Device.
[illegible]	Method of Maki
[illegible]	Boiling Water R
[illegible]	Nuclear Reactor
[illegible]	Process of Maki Fuel Element
[illegible]	Steam Forming Method of Op
[illegible]	Method of Prep
[illegible]	Sintering Metal
[illegible]	Alloy Member a The Same.
[illegible]	Nuclear Superhe Reactor.
[illegible]	Neutronic React
[illegible]	Compartmented
[illegible]	Gas-Cooled Neu

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FRENCH PATENTS—Continued

Patent No.	Title	Patent No.	Title
[illegible] 848	Concentric Tubular Fuel Element.	1, 252, 036	Plasma Pressure Balancing Means.
[illegible] 162	Accelerometer.	1, 252, 430	A Method of Preparing Fuel Elements for Nuclear Reactors.
[illegible] 368	Method of Reducing Aqueous Radioactive Nuclear Wastes to Solid Form.	1, 253, 182	Neutronic Reactor Control Rod and Method of Fabrication.
[illegible] 458	Merchant Marine Ship Reactor.	1, 254, 109	Uranium Base Alloy.
[illegible] 486	Improved Process for the Preparation of Uranium Tetrafluoride from Uranium Dioxide.	1, 254, 206	Continuous Process for Preparing Uranium Hexafluoride From Uranium Tetrafluoride and Oxygen.
[illegible] 758	Catalyst.		
[illegible] 181	Nuclear Propelled Vehicle.	1, 255, 181	Nuclear Reactor.
[illegible] 261	Fuel Element for a Nuclear Reactor.	1, 255, 278	High Temperature Reduction of Uranium Hexafluoride to Metal.
[illegible] 178	Moderator Elements for Uniform Power Nuclear Reactor.	1, 256, 914	Eccentric Rolling of Powder and Bonding Agent into Spherical Pellets.
[illegible] 812	Ultrasonic Neutron Dosimeter.		
[illegible] 767	Dissolution of Zirconium-Containing Fuel Elements.	1, 258, 461	Gas Separator.
[illegible] 858	Fluidized Solids Process and Recovery of Uranium from Zirconium-Type Fuel Element.	1, 259, 165	Neutronic Reactor Control Element.
		1, 260, 309	Fused Reactor Fuels.

ITALIAN PATENTS

[illegible] 163	Electronic Master Slave Manipulator.	606, 396	Method for Producing High Strength Control Rods for Neutronic Reactors and Control Rods Produced Thereby.
[illegible] 004	Neutronic Reactor Control.		
[illegible] 781	Composite Element and Method of Manufacture.	607, 240	Nuclear Reactor.
[illegible] 998	Method and Apparatus for Reactor Safety Control.	612, 546	Plutonium-Cerium-Cobalt and Plutonium-Cerium-Nickel Alloys.
[illegible] 623	Method of Operating Nuclear Reactor.	612, 548	Fused Salt Process for Recovery of Values from Used Nuclear Reactor Fuels.
[illegible] 736	Fluoride Volatility Process for the Recovery of Uranium.		
[illegible] 431	Process for Separation of Protactinium, Thorium and Uranium from Neutron-Irradiated Thorium.	612, 587	Composite Fuel Element.
		613, 591	Fuel Element.
		613, 644	Reactor Control.
[illegible] 360	Accelerometer.	614, 930	Heat Transfer Device.
[illegible] 771	Uranium Recovery Process.	615, 128	Nuclear Fuel Material.
[illegible] 967	Nuclear Reactor Including a Package Safety Device.	615, 134	Fuel Element Construction.
		615, 138	Method of Making Fuel Bodies.
[illegible] 529	Method of Making Fuel Elements.	616, 576	Fuel Element for a Nuclear Reactor.
[illegible] 640	Boiling Water Reactor	616, 579	Moderator Elements for Uniform Power Nuclear Reactor.
[illegible] 638	Nuclear Reactor Core Design.		
[illegible] 604	Process of Making a Neutronic Reactor Fuel Element Composition.	616, 613	Nuclear Reactor.
		616, 614	Uranium Base Alloy.
[illegible] 954	Steam Forming Neutronic Reactor and Method of Operating it.	616, 597	Fluidized Solids Process and Recovery of Uranium from Zirconium-Type Fuel Element.
[illegible] 772	Method of Preparing a Fuel Element.		
[illegible] 810	Sintering Metal Oxides.	616, 598	Dissolution of Zirconium-Containing Fuel Elements.
[illegible] 916	Alloy Member and Process for Making The Same.	616, 599	A Method of Preparing Fuel Elements for Nuclear Reactors.
[illegible] 492	Nuclear Superheater for Boiling Water Reactor.	616, 825	Thermoelectric Cell and Reactor.
[illegible] 716	Neutronic Reactor Fuel Element.	617, 414	Fuel Element.
[illegible] 723	Compartmented Reactor Fuel Element.	617, 430	Fused Reactor Fuels.
[illegible] 726	Gas-Cooled Neutronic Reactor.		

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APPENDIX 6

Publications of the U.S. Atomic Energy Commission

The U.S. Atomic Energy Commission sponsors the publication of books, technical reviews, research and development reports, and monographs to disseminate technical information on atomic energy; further, the Commission encourages the publication of research results in scientific and technical journals. In addition, the AEC publishes abstract journals to expedite the dissemination of nuclear-energy information to the world-wide scientific community; each abstract gives the availability of the item abstracted. AEC research and development information, not available through commercial channels, is made available either through the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., or through the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Availability and pricing for all reports abstracted in *Nuclear Science Abstracts* since July 1947 are given in TID–4000 (6th Rev.), which is available from the Office of Technical Services. *Nuclear Science Abstracts* not only announces and indexes the newly released AEC reports but also gives the same coverage for world-wide nuclear-energy literature.

The publications described in this Appendix are representative of the information published or sponsored by the Commission and made available during 1961.

GENERAL PUBLICATIONS

Atomic Energy Research in the Life and Physical Sciences—1960. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, January 1961. 175 pages. $1.25. Basic research financed by the Atomic Energy Commission separates broadly into work in the life and the physical sciences. This report indicates the range of events and findings in research carried out in Commission-owned and -financed laboratories during 1960, with emphasis on the findings that give some indication of future usefulness in science, in manufacturing, in medicine, or in other applications.

Cancer Research Program of the Division of Biology and Medicine (TID–11132). U.S. Atomic Energy Commission, 1960. 100 pages. $0.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Describes the programs and facilities of seven installations engaged in the major portion of the Atomic Energy Commission's cancer research including five which are associated with national laboratories or special AEC projects. Also includes brief descriptions of other research programs supported at several universities, medical schools, and hospitals in the United States.

The Community Impact of Peaceful Applications of Atomic Energy (TID–8202). By Harold Sandbank. U.S. Atomic Energy Commission, Washington, 1960. 80 pages. $1.00. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report deals with the impact on cities and towns resulting from the peaceful applications of atomic energy. It is based on a study made by the American Municipal Association under a contract with the Commission. The work started in December 1958 to study the following areas: extent of peaceful uses of

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nuclear materials
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standards and re
sources of inforn
officials.

Costs of Nuclear Po
1961. 43 pages.
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Fossil Fuels in the
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appendixes.

Genetics Research
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Presents summari
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IAEA Research Proj
ington, 1961. 16 p
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Marine Sciences Res
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nuclear materials, effects on localities and local government functions, programs of federal and state agencies and other groups active in the field, standards and requirements controlling the use of nuclear materials, and sources of information and assistance available to communities and local officials.

Costs of Nuclear Power (TID–8531, Rev. 1). U.S. Atomic Energy Commission, 1961. 43 pages. $0.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Discusses costs of nuclear power from stationary plants primarily designed for generation of electricity. Covers those reactors in operation, being built, or planned as of January 1961. Provides definitions and assumptions on which comparative power costs have been estimated for nuclear versus comparable fossil-fuel plants.

Fossil Fuels in the Future (TID–8209). By Milton F. Searl. U.S. Atomic Energy Commission, Washington, 1960. 63 pages. $0.75. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report reviews the extent of fossil-fuel resources and forecasts the rate at which these will be depleted in the absence of new sources of energy, in order to estimate the earliest time when large amounts of nuclear power will be needed. Energy projections are included for the United States, other areas, and the world as a whole. The bases for the estimates used, as well as other forecasts and divergent opinions, are included as appendixes.

Genetics Research (TID–4041). U.S. Atomic Energy Commission, 1961. 120 pages. $1.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Another in a series of publications describing research supported by the USAEC Division of Biology and Medicine. Presents summaries of 55 contracts with various educational and research institutions in this country and abroad concerned with genetic hazards of radiation in plant and animal life.

IAEA Research Projects (TID–11404). U.S. Atomic Energy Commission, Washington, 1961. 16 pages. No charge. (Available from the U.S. Atomic Energy Commission, Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., on request.) Summaries of the research contracts awarded and supported by the International Atomic Energy Agency to the end of December 31, 1960, are included. The research contracts are divided into eight areas: (1) safe disposal of radioactive waste, (2) health physics and radiation protection, (3) radiobiology, (4) safeguards, (5) power reactor studies, (6) application of radioisotopes in medicine, (7) application of radioisotopes in agriculture, and (8) miscellaneous.

Marine Sciences Research (TID–4040). U.S. Atomic Energy Commission, 1961. 42 pages. $0.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) One of a series of publications describing research supported by the AEC's Division of Biology and Medicine. Presents 28 summaries of contracts concerned with research on effects of atomic radiation on aquatic organisms.

U.S. Atomic Energy Commission Motion Picture Film Library—Popular Level, 16-mm. U.S. Atomic Energy Commission, Washington, January 1961. 27 pages. No charge. (Available from the Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., on request.) This brochure describes 85 of the USAEC-sponsored films designed to better acquaint students and the public with the far-reaching aspects of atomic energy. The descriptions are grouped in broad subject categories. The title, producer, running time, educational level, and charge for each film together with complete ordering instructions are included.

U.S. Atomic Energy Commission Motion Picture Film List—Professional Level. U.S. Atomic Energy Commission, 1961. No charge. (Available from the U.S. Atomic Energy Commission, Office of Technical Information Service Extension, P.O. Box 62, Oak Ridge, Tenn.)

Nuclear Reactors Built, Being Built, or Planned in the United States as of June 30, 1961 (TID–8200, 4th Rev.). U.S. Atomic Energy Commission, 1961. 27 pages. No charge. (Available from U.S. Atomic Energy Commission, Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn.) Information is presented in five parts, categorized by primary function or purpose. The first four categories include civilian, military, production, and experimental reactors. The fifth is devoted to critical assemblies.

18 Questions and Answers About Radiation. U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office, 1960. 47 pages. $0.25. This booklet answers frequently asked questions about radiation in brief and nontechnical form. The questions answered give a simplified presentation of the broad subject scope of radiation, fallout, effects, and protection guides, along with a brief explanation of the value of atomic energy. An appendix reprints a Memorandum for the President on "Radiation Protection Guidance for Federal Agencies."

Questions & Answers on U.S. Atomic Energy Commission Access Permits (TID–4558, 3rd Rev.). U.S. Atomic Energy Commission, 1961. 12 pages. No charge. (Available from the U.S. Atomic Energy Commission, Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tennessee, on request.) This brochure provides answers to most frequently asked questions concerning the USAEC Access Permit Program. Subjects covered include: Access Permit application, personnel access, report availability and storage, authorization to visit AEC sites, permit amendment and renewal, and security aspects of the program.

TECHNICAL PUBLICATIONS

Books

Applied Gamma-Ray Spectrometry. C. E. Crouthamel of Argonne National Laboratory, editor. Pergamon Press, 1960. 443 pages. $6.50. This book is the outgrowth of the rapidly increasing and widespread application of gamma-ray spectrometry to many fields other than nuclear physics. For example, chemists, biologists, engineers, and other research workers using scintillation spectrometers and proportional gas spectrometers will face the task of interpreting the gamma-ray spectra. The Crouthamel volume should prove useful both as a reference work for these individuals engaged in research and as a supplementary text in radiochemical and analytical instruments courses.

Fast Reactor Cross Sections. S. Yiftah, D. Okrent, and P. A. Moldauer. Pergamon Press, 1960. 130 pages. $5. A study at Argonne National Laboratory designed to construct a new 16-group cross section set. Efforts are made to explain and document all choices and assumptions. The constants were arrived at by reviewing available experimental data, together with theoretical estimates where such data were unavailable. Gaps, conflicts, and inconsistencies in the data are pointed out.

Introduction to Nonlinear Differential Equations, by H. T. Davis. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, 1961. 306 pages. $2.00. An attempt is made in this publication to attain a modest measure of completeness in defining the field of nonlinear problems. A general

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survey of the problem presented by nonlinear equations; a study of the differential equation of first order; classical theories of integration, the integrating factor, particular equations and the problem of singular solutions are discussed; and a systematic study of the Riccati equation, chosen because of its wide application and illustration of many of the differences between linear and nonlinear problem are presented in the Introduction. Other subjects considered include critical examination of existence theorems and the algorithms which they contain. Before proceeding to the more general matters of this study, the author considers two particular problems: Volterra's theory of the growth of conflicting populations and the problem of pursuit.

Introduction to Nuclear Science. Alvin Glassner. Princeton, D. Van Nostrand Company, Inc., 1961. 213 pages. $3.75. This book is an outgrowth of the intensive course for high-school teachers developed by a committee of the Argonne National Laboratory Branch of the Scientific Research Society of America. Included are a brief review of atomic structure, discussion of the most recent detection methods and the known forms of radiation, description of the nucleus and nuclear reactions, survey of accelerators and reactors, and applications of nuclear science in chemistry and biology. The book is basic in content in order to narrow the gap between the training of the average high-school teacher and the current state of scientific knowledge.

The Metal Plutonium. Drs. A. S. Coffinberry and W. N. Miner, editors. University of Chicago Press, 1961. $9.50. This book's carefully planned assemblage of papers by plutonium pioneers will be, we believe, an essential volume in the libraries of scientists and engineers interested in the properties and applications of plutonium. The introductory section gives comprehensive background; the middle section covers physical metallurgy and projects at various laboratories; the concluding chapters describe applications in reactor fuels. The contents are: Section I. Historical review. Section II. Plutonium metallurgy. Section III. Plutonium in nuclear reactors. Index.

Nuclear Reactor Fuel Elements, Metallurgy and Fabrication. Dr. Albert R. Kaufmann, Editor. Interscience Publishing Co., 1961. $27. Energy from nuclear fission. Fuel-element problems. Uranium and its alloys. Plutonium and its alloys. Thorium and its alloys. Uranium dioxide and other ceramic fuels. Cladding materials. Interactions between core and cladding. Behavior of fissionable material under irradiation. Engineering aspects of fuel elements. Fabrication of core materials. Cladding and bonding techniques. Fuel sub-assembly concepts. Inspection and testing. Description and performance of operational fuel elements. Processing irradiated fuel elements. Fluid-fuel systems. Fuel-element economics. Appendix A: Phase diagrams. Appendix B: Fuel-element fabrication facilities. Appendix C: Glossary.

Principles of Cyclic Particle Accelerators. John J. Livingood. D. Van Nostrand Co., Inc., 1961. 392 pages. $10.75. Planned for the novice, this book by the Senior Physicist of Argonne National Laboratory's Physics Division introduces the subject from the very beginning and gives a reader a quantitative understanding of the basic principles of the large variety of particle accelerators now existing. Emphasis is largely on the dynamics of the particle, in the linear approximation.

Proceedings of an International Conference on Instrumentation for High-Energy Physics. New York, Interscience Publishers, Inc., 1961. 321 pages. $10. The 1960 International Conference on Instrumentation for High-Energy Physics, sponsored jointly by the U.S. Atomic Energy Commission and International Union for Pure and Applied Physics, was held at the Lawrence Radiation Laboratory, University of California, Berkeley. The compilation

includes the papers, round table discussions, and discussion periods from the conference.

Radiation Uses in Industry and Science, by Lloyd E. Brownell. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, 1961. 431 pages. $2.50. This book is intended to be a panorama of radiation applications and potentialities in the nonpower uses of atomic energy (exclusive of medicine). The reference portions have been prepared to provide greater detail for those who wish to find more information in their own specialties. Subjects treated include: physical principles of radiation, radioisotopes, controlled nuclear fission; reactors as industrial sources of radiation; industrial applications of radiation; radioisotopes for use in tracer studies and autoradiography; agriculture applications; effects of ionizing radiation; radiation effects on biological materials, simple organisms, plants, foods, and pharmaceuticals; possible applications of the biological effects of gamma radiation; and a survey of instruments and techniques used in radiation detection and measurement.

Rare Earth Alloys. Dr. Karl A. Gschneidner, Jr. D. Van Nostrand Company, Inc., 1961. 449 pages. $12.75. General considerations and electronic structure. Atomic properties and crystal structures. Transformation, melting temperatures, heats of transformation, and fusion. Vaporization and boiling point data. Heat capacities and related functions. Magnetic, electrical, electronic, engineering, and mechanical properties. Miscellaneous properties. General alloying theory. Intra-rare-earth binary alloy systems. Binary alloy systems of a rare-earth metal with a non-rare element. Ternary alloy systems containing one and two rare-earth metals. Quaternary alloy systems containing one rare-earth metal. Structural details of the crystallographic species. Appendix list of abbreviations and terms used in the book. Indexes.

The Rare Earths. Drs. F. H. Spedding and A. H. Daane, editors. John Wiley & Sons, Inc., 1961. 641 pages. $14.75. Historical introduction. Chemistry, occurrence, and strategic supply of the rare earths. Separation of the rare earths by fractional crystallization, by liquid-liquid extraction, and by ion exchange. Preparation of the rare-earth fluorides. Rare-earth and yttrium halides for metal production—chlorides, bromides, iodides. Metallothermic preparation of rare-earth metals. Rare-earth electrolytic metals. Refining, purification, and mechanical fabrication of rare-earth metals. Physical properties, crystallography, and metallography of the rare-earth metals. Rare-earth metal phase diagrams. Principles of alloying behavior of rare-earth metals. Mechanical properties of yttrium, scandium, and the rare-earth metals. Rare-earth metals in magnesium technology. Applications of rare earths to ferrous and nonferrous alloys. Nonnuclear, nonmetallic uses of rare earths. Nuclear applications of yttrium and the lanthanons. Analytical chemistry and spectroscopy of rare earths.

Reactor Handbook, Fuel Reprocessing, Vol II, 2nd Edition. S. M. Stoller, editor. Interscience Publishers, Inc., 1961. $22. 665 pages. Part A: Introduction: Reactor system effects. Reprocessing and reconversion economics. Part B: Aqueous Separations Processes: Head-end processes for solid fuels. Aqueous separation. Reprocessing of aqueous fuel. Fluoride and other halide volatility processes. Part C: Non-aqueous separations processes. Part D: Reconversions: Natural, slightly enriched, or depleted uranium chemistry. Highly enriched or fully enriched uranium chemistry. Thorium chemical reconversions. Plutonium reconversions. Isotopic enrichment. Part E: Radioactive Waste Disposal: Gaseous waste. Liquid waste treatment and disposal. Solid wastes. Part F: Engineering: Plant design. Equipment design—process and mechanical considerations. Plant management.

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Reactor Handbook, Physics and Shielding, Vol. III, 2nd Edition. H. Soodak, editor. Interscience Publishers, Inc., 1961. In 2 parts: Part A: Nuclear data. Experimental methods. Theory of neutron transport. Reactor statics, theoretical. Reactor dynamics. Critical data. Part B: Radiation Shielding. Introduction: Shield design criteria and procedures. Sources of neutrons and gamma rays. Neutron attenuation. Gamma-ray attenuation. Analytical methods of shield design. Ducts and voids in shields. Heat generation in shields. Shield optimization with respect to weight. Air, ground, and structure scattering of radiation.

Uranium Dioxide: Properties and Nuclear Applications. Edited by J. Belle. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, 1961. 726 pages. $2.50. This is the fourth book on reactor materials published under the sponsorship of the USAEC Naval Reactors Branch. This book represents the technology developed on uranium dioxide for power reactors. The work surveys the properties and nuclear applications of UO_2, the development of which as a fuel material is still in an early stage. Foreword by Vice Admiral H. G. Rickover.

MANUALS, HANDBOOKS AND REPORTS

Comparative Nuclear Effects of Biomedical Interest (CEX-58.8). U.S. Atomic Energy Commission, 1960. 83 pages. $1. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Clayton S. White, I. Gerald Bowen, Donald P. Richmond and Robert L. Corsbie. A joint effort of the Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex., and the United States Atomic Energy Commission, Division of Biology and Medicine. This report presents selected physical and biological data bearing upon the environmental variations created by nuclear explosions with emphasis on early consequences of exposure to blast, thermal radiation, and ionizing radiation. Describes comparative ranges of major effects varying with explosive yield as contributing to total hazard to man. Includes definitions of terminology and tables of sequential physical and biological effects.

Current Outstanding Problems in Reactor Physics (TID-8210). U.S. Atomic Energy Commission, 1961. 30 pages. $0.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) An appraisal by the USAEC Advisory Committee on Reactor Physics for reference use and guidance of research centers engaged in theoretical and experimental reactor physics investigations. The report emphasizes significant problem areas, illustrates reactor physics and technology which might be applied, and suggests an order of priority for problem resolution.

Laboratory Experiments with Radioisotopes for High School Science Demonstrations. Edited by Samuel Schenberg. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, Revised 1958, Reprinted 1961. 50 pages. $0.35. This book is the outgrowth of an in-service training program cosponsored by the Board of Education, City of New York, and the New York Operations Office of the U.S. Atomic Energy Commission. Included are twenty experiments for use in high-school laboratories and four appendixes: I, Radioactivity and its measurement; II, Safe handling of radioisotopes; III, Commonly used radioisotopes; and IV, bibliography.

Nuclear Fuels and Materials Development (TID-11295). U.S. Atomic Energy Commission, 1961. 172 pages. $2.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A summary of progress by the Atomic Energy Commission's Division of Reactor Develop-

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ment on the Nuclear Technology Program to increase knowledge of, and effect improvements in, reactor materials. Describes research on a variety of fuel materials and moderators and on nondestructive testing of reactor components.

Nuclear Safety Guide (TID–7016, 1st Rev.). U.S. Atomic Energy Commission, 42 pages. $0.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) An up-to-date issuance of recommendations for arrays of individually subcritical fissionable material units that may be applied to processing plant layout, to storage, and to the arrangement of materials in shipment. Defines nuclear safety problems, recommends nuclear safety limit levels, and provides examples of safe applications. Includes 47 references and a comprehensive reading list.

1960 Nuclear Data Tables. Part 1. Consistent Set of Q-Values I ($A \leq 66$). Part 2. Consistent Set of Q-Values II ($67 \leq A \leq 199$). Part 3. Nuclear Reaction Graphs. Edited by K. Way. U.S. Atomic Energy Commission, Washington. U.S. Government Printing Office, 1961. Part 1, 214 pages. $1.50. Part 2, 456 pages. $2.75. Part 3, 181 pages. $1.25. Parts 1 and 2 present reaction Q-Values computed from masses obtained from a new least-squares adjustment based on the most accurate experimental results of nuclear reaction work, beta disintegration, and mass spectroscopic studies. Part 3 presents a collection of 69 graphs exhibiting range-energy relations, cross sections for neutron production, crystal efficiencies, conversion factors, calibration energies, and other data frequently needed in nuclear reaction studies. Another part, Part 4, Short Tables, presents compilations of recent experimental results on nuclear radii, beta disintegration energies, nuclear scattering, neutron thresholds, gamma-ray energies, thermal-neutron cross sections, nuclear moments, reaction Q-Values, and the second supplement to the Directory to Nuclear Data Tabulations is in preparation.

Plutonium Ion Exchange Processes (TID–7607). U.S. Atomic Energy Commission, 1960. 77 pages. $2. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A collection of 9 papers presented at a United States-United Kingdom Technical Exchange Meeting held at Oak Ridge, Tenn., April 25–27, 1960. The papers are principally concerned with plutonium separation by anion and cation exchange with brief treatment of ion exchange contactors, amine extraction of plutonium, and uranium recovery from reduction residues.

The Practical Application of Space Nuclear Power in the 1960's (TID–6312). U.S. Atomic Energy Commission, 1961. 50 pages. $1.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A publication prepared for the Commission by North American Aviation, Inc., Canoga Park, Calif., on nuclear reactor space electric power units under development in the U.S. Units described are in the Systems for Nuclear Auxiliary Power (SNAP), ranging in energy from 300 watts to 60 kilowatts. Those described are SNAP–2, SNAP–8, and SNAP–10, and information is provided on major operational, installation, and handling characteristics with emphasis on payload restrictions, shielding, and radiation environment. Ground handling, and safety, and aspects of space reactor utilization are included.

Program of the United States Government in Atmospheric Radioactivity (TID–6947). U.S. Atomic Energy Commission, 1961. 14 pages. $0.30. (Available from Office of Superintendent of Documents, U.S. Department of Commerce, Washington 25, D.C.) An outline of the current program of fall-out studies sponsored by the Atomic Energy Commission and other Government agencies. Aims and objectives of the program are discussed.

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Radiochemical Techniques. Subcommittee on Radiochemistry of the Committee on Nuclear Science of the National Academy of Sciences—National Research Council. U.S. Atomic Energy Commission. (A series of monographs, separately priced, available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Each monograph in this series collects in one volume the pertinent information required for radiochemical work with a specialized element or with a specialized technique. Written by an expert in the field, each monograph presents information current as of the date issued. Monographs on the following techniques have been issued: Liquid-Liquid Extraction With High Molecular Weight Amines, Solvent Extraction With Phosphine Oxides, Low Level Radiochemistry, Chromatography and Electromigration, Processing of Counting Data, Rapid Radiochemical Separations, Thin Films, Distillation, Column Separation Techniques, and Low Level Counting.

Radiochemistry of the Elements. Subcommittee on Radiochemistry of the Committee on Nuclear Science of the National Academy of Sciences—National Research Council. U.S. Atomic Energy Commission. (A series of monographs, separately priced, available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Intended for the working scientist, each monograph collects the pertinent information required for radiochemical work with an individual element or a group of related elements. Monographs on the following elements have been issued: Aluminum and Gallium, Antimony, Beryllium, Carbon-Nitrogen and Oxygen, Cesium, Copper, Gold, Indium, Iron, Magnesium, Manganese, Mercury, Polonium, Protactinium, Rare Earths—Scandium, Yttrium and Actinium, Rare Gases, Rhenium, Ruthenium, Selenium, Technetium, Tellurium, Tin, Titanium, Transuranic Elements, Vanadium, Zinc.

Radioisotope Experiments for the Chemistry Curriculum (TID-6374). Edited by Norman Radin. U.S. Atomic Energy Commission, Washington, 1960. 184 pages. $2. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Training manual designed to provide background and a variety of experiments to teach the use of radioisotopes in the chemistry curriculum. Experiments are organized into two areas: general introductory and chemistry experiments. Chemistry experiments are divided into seven areas: introductory, qualitative and quantitative analysis, organic, physical, instrumental analysis, and biochemistry. A table of useful radioisotopes is included as an appendix. TID-6375 is the instructor's manual for this manual.

Radioisotope Experiments for the Chemistry Curriculum—Instructor Notes (TID-6375). U.S. Atomic Energy Commission, Washington, 1960. 60 pages. $1. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Designed as an instructor's manual for TID-6374, q.v., this publication provides general information for the course and specific information for each experiment outlined in the training manual. A listing of the equipment and reagents required for the chemistry experiments is included as an appendix.

Radioisotopes in World Industry—Abstracts of Selected Foreign Literature (TID-6613). U.S. Atomic Energy Commission, 1961. 144 pages. $2.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Abstracts 658 articles and publications published in languages other than English during 1959 and 1960, covering applications of radioisotopes by world-wide science and industry. The abstracts are grouped by subject and subgrouped by country. Includes author and country indexes as well as an index correlating abstract numbers with reference numbers

assigned sequentially by the Library of Congress to the original literature items.

Possible Requirements for Radioisotopes as Power Sources (TID-12711). By William H. McVey. U.S. Atomic Energy Commission, Washington, 1961. 14 pages. $0.50. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Presents status as of October 1960 of possible large-scale uses of separated fission products and certain alpha-emitting isotopes in operational quantities, exceeding availability and market.

Shaft Seals for Compressors and Turbines for Gas-Cooled Reactor Application (TID-7604). U.S. Atomic Energy Commission, 1961. 242 pages. $1. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A compilation of papers and discussions presented at a meeting held at Oak Ridge National Laboratory, December 16-17, 1959, to discuss development problems associated with shaft seals for compressors and turbines for use in gas-cooled reactors. Twenty-one papers are included from sessions on special seal programs, floating bushing (sleeve), and other types of seals, back diffusion and metallurgical problems and compressors for in-pile loops and reactor auxiliary use.

Special Sources of Information on Radioisotopes (TID-4563). U.S. Atomic Energy Commission, 1961. 58 pages. No charge. (Available from the U.S. Atomic Energy Commission, Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tennessee, on request.) Selected sources of information are presented on radioisotope applications, availability and potential value, and sources of educational material and programs of assistance and development.

Strontium-90 on the Earth's Surface (TID-6567). U.S. Atomic Energy Commission. 25 pages. $0.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Present results of a worldwide survey of Sr-90 fall-out conducted in 1959 by the U.S. Department of Agriculture, Soil Conservation Service; the USAEC Health and Safety Laboratory; and the U.S. Department of Commerce, Weather Bureau. Data are presented based on analysis of soil samples from selected sites which were processed identically in an effort to produce uniform results. Meteorological influences on deposition and redistribution are considered. Estimates are provided for incremental increases in Sr-90 fall-out between sampling in 1956, 1958, and 1959.

Summaries of Fuels and Materials Development Programs (TID-6506). U.S. Atomic Energy Commission, 1960. 108 pages. $2.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report summarizes individual research projects supported by the Fuels and Materials Development Branch, Nuclear Technology, Division of Reactor Development. Information is provided on research conducted at the Commission's laboratories and at industrial, university, and other laboratories.

Small Power Reactors (TID-8535). U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, 1961. 132 pages. $1. The subject report represents one of the two areas not covered in the 1959 Civilian Power Reactor studies published by the Commission. The small power reactors, those below 75 Mw(e), are considered in this study, including the current status, research and development program, and economic status as of June 30, 1960. The other area not covered in the 1959 studies, process reactors, will be reported in separate reports. Small power reactors are of interest in the Civilian Power Reactor considerations to consumer-owned, cooperatively owned, and remotely located utilities.

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ytical Chemistry in Nuclear Reactor Technology, Fourth Conference, Gat-burg, Tenn., October 12–14, 1960 (TID–7606). U.S. Atomic Energy Com-ssion, 1961. 427 pages. $4.25. (Available from the Office of Technical rvices, U.S. Department of Commerce, Washington 25, D.C.) This pub-ation summarizes much of the recent work on the development or improve-ent of methods, facilities, and instruments for the analysis of nuclear ctor materials or related substances. The papers which appear were con-ributed by 88 writers in 22 different centers of nuclear energy development roughout the United States and in three foreign countries. With few ex-ptions, the authors of these papers are actively engaged in the analysis of ctor materials. The scope and diversity of subject matter covered in these pers attest to the ingenuity, resourcefulness, and enterprise which these alytical chemists and their collaborators, the instrument makers, have isplayed in providing the analytical services essential to progress in the er-expanding field of nuclear reactor technology.

Annual Meeting of the Bio-Assay and Analytical Chemistry Group TID–7591). U.S. Atomic Energy Commission, 1960. 109 pages. $2.25. Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) The proceedings of the fifth meeting of the bio-assay d analytical chemistry group to interchange information in the field of alth protection is reported. Areas reported include bio-assay, health radio-emistry, occupational biochemistry, and radiation-hygiene chemistry.

ation of Radioactivity in Stable, Solid Media (TID–7613). U.S. Atomic ergy Commission, 1960. 782 pages (2 books). $8. (Available from ice of Technical Services, U.S. Department of Commerce, Washington 25, C.) This publication reports the second working meeting on the fixation radioactivity in stable, solid media held in September 1960; an earlier meet-g was held in 1957. The purpose of this meeting was to review the prog-ss made in transforming liquids and fixing radioactivity in a solid form in is country and abroad. Five seminar type working meetings were devoted to oblems involving radiant heat spray, fluidized bed, pot and rotary kiln lcination, as well as fixation in glass, ion exchange and the associated prob-ms of off-gas cleaning materials of construction and characteristics of solids, d final disposal.

lear Reactor Chemistry (TID–7610). U.S. Atomic Energy Commission, 1960. 0 pages. $1.75. (Available from Office of Technical Services, U.S. Depart-nt of Commerce, Washington 25, D.C.) This report contains 38 papers sented at a first conference of a planned series on chemical aspects of clear reactor technology particularly as related to the chemical behavior reactor materials as opposed to engineering applications. Subjects include mical behavior of fission products, corrosion, radiation effects, and fuel and nket systems.

eedings of the Beryllium Oxide Meeting Held at Oak Ridge National aboratory, Oak Ridge, Tenn., December 1–2, 1960 (TID–7602, Part 1). Atomic Energy Commission, 1961. 38 pages. $0.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington D.C.) This report presents summaries of information and plans for ure work on beryllium oxide for high-temperature reactor applications pre-ted at a meeting of AEC contractors held at ORNL late in 1960. Installa-ns represented at this meeting included: Aerojet-General Nucleonics, Battelle morial Institute, General Atomics, Los Alamos Scientific Laboratory, and

Proceedings of the Eighth Conference on Hot Laboratories and Equipment (TID–7599). U.S. Atomic Energy Commission, 1960. 556 pages. $3.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A compilation of fifty-two papers presented at a meeting held December 13–16, 1960, in San Francisco. Some of the topics covered are: hot laboratory facilities and hot cells, general purpose manipulators, viewing equipment, shielding and experiments, glovebox design, and specialized equipment.

Proceedings of the High Temperature Gas-cooled Civilian Power Reactor Conference—January 17–18, 1961 (TID–7611). U.S. Atomic Energy Commission, 1961. 192 pages. $2.25. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Held in San Francisco, the purpose of this conference was to inform industrial, municipal, and other groups of the status of the Civilian Power Reactor Program. The HTGR is being designed and constructed under a cooperative agreement with the Commission and the High Temperature Reactor Development Associates, Inc. Papers consider design, theoretical physics, and experimental procedure for developing the HTGR.

Proceedings of the Symposium on Nondestructive Testing Trends in the AEC Reactor Program (TID–7600). U.S. Atomic Energy Commission, Washington, 1961. 86 pages. $2. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This presentation includes papers presented by AEC contractor personnel in the symposium on Nondestructive Testing Trends in the AEC Reactor Program, held at Commission headquarters, Germantown, May 20, 1960. The purpose of the symposium was to acquaint industry representatives with the equipment and techniques used in nondestructive testing as performed by the Commission.

Sixth Air Cleaning Conference (TID–7593). U.S. Atomic Energy Commission, 1960. 393 pages. $4. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A compilation of technical papers, notes, and transcripts from a meeting held in October 1960 at Harvard University. The meeting covered air cleaning activities at AEC installations in areas of practical field experience with effluent decontamination from reactors and fuel fabrication.

U.S. Papers Presented at the Fifth Nuclear Congress, Rome, Italy, 1960 (TID–7601). U.S. Atomic Energy Commission, 1960. 98 pages. $2.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A collection of eight U.S. papers is included which discuss aims and techniques of technical and public information in nuclear plant activities, isotope production and separation at Oak Ridge and Brookhaven National Laboratories, and other installations, and aspects of radiobiology and radio-epidemiology.

Nuclear Superheat Meeting (TID–7595). U.S. Atomic Energy Commission, 1959. 48 pages. $0.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) The first of a planned series of Atomic Energy Commission sponsored meetings with representatives of four contractors active in the field of nuclear superheat. Conducted in the nature of technical seminars, this meeting held at San Jose, Calif., on November 3, 1959, emphasized engineering data development and problem experience and resolution theory. This first meeting was unique in presenting contractor plans, reactor and test facility designs, and schedules.

Nuclear Superheat Meeting (TID–7596). U.S. Atomic Energy Commission, 1960. 50 pages. $1.25. (Available from Office of Technical Services, U.S.

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Department of Commerce, Washington 25, D.C.) Second in the series of meetings with nuclear superheat contractors sponsored by the Atomic Energy Commission, held at Dunedin, Fla., April 7–8, 1960. This compilation includes presentations by Combustion Enginering, Inc., Allis-Chalmers Manufacturing Co., Argonne National Laboratory, General Electric Co., and Atomics International. Particular emphasis was given development of engineering data since the first meeting.

Nuclear Superheat Meeting (TID–7609). U.S. Atomic Energy Commission, 1960. 130 pages. $2.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Third in a series of technical seminars, this meeting was held in Chicago, Ill., on November 10, 1960. Further review was made of engineering data developed since the previous meeting. Discussions on reactors included: Pathfinder EBWR, BORAX V, VUSU, BONUS, and others which are under construction or planned.

Symposium on Particle-Fluid Interactions (TID–7592). U.S. Atomic Energy Commission, 1960. 97 pages. $1. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A meeting held at the USAEC New York Operations Office, May 1959. This report contains the full text of 13 papers and abstracts of 10 others, which describe various programs for investigating particle-fluid interactions and their applications in studying reactor concepts.

Proceedings of the Power Reactor In-Core Instrumentation Meeting (TID–7598). U.S. Atomic Energy Commission, 1960. 115 pages. $2.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A compilation of six papers presented at a meeting held in Washington, D.C., April 28–29, 1960, together with separate discussions conducted during the meeting. Current programs for development of in-core instrumentation are reviewed with particular reference to applications in reactors whose coolant systems utilize water, organic materials, liquid metals, and gas.

Proceedings of the Total Absorption Gamma-Ray Spectrometry Symposium (TID–7594). U.S. Atomic Energy Commission, 1960. 253 pages. $3.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Presents 24 papers presented at Gatlinburg, Tennessee, on May 10–11, 1960, at a meeting on the application of very large scintillators, particularly sodium iodide crystals for gamma-ray spectroscopy.

Proceedings of the University Reactors Conference Held at Gatlinburg, Tennessee, August 17–19, 1960 (TID–7608). U.S. Atomic Energy Commission, 1961. 201 pages. $3. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Papers and discussions are included on the practicability of university reactors, safety aspects, procurement and availability, construction, operation, and the future role of university reactors. The meeting also considers types of reactors that will best meet the needs of university training programs opposed to the needs of university research.

Proceedings of the Uranium Carbide Meeting Held at Oak Ridge National Laboratory, Oak Ridge, Tenn., December 1–2, 1960 (TID–7603). U.S. Atomic Energy Commission, 1961. 162 pages. $1.75. (Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C.) The proceedings of this meeting represent the third of an informal series of meetings on uranium carbides to exchange information and plans. Of all the refractory uranium compounds, the carbides offer the most promise of development into fuel materials which could be superior to uranium dioxide for some applications. Presently contracted work includes research on the preparation

and fabrication of uranium carbides, determination of physical and mechanical properties, irradiation testing, fuel element testing, and recycling. Other work on uranium carbides is being conducted at various laboratories in connection with specific reactor projects.

Proceedings of the Symposium on Uranium Carbides as Reactor Fuel Materials Held at Atomic Energy Commission Headquarters Building, Germantown, Maryland, April 4, 1961 (TID–7614). U.S. Atomic Energy Commission, Washington, 1961. 147 pages. $1.50. This report covers the proceedings of meeting which was held, as a part of the Commission's continuing efforts to strengthen and broaden industrial capability in the atomic energy field, to acquaint private industry and other interested parties with the research being conducted by the AEC to develop uranium monocarbide and uranium dicarbide as fuel materials for nuclear reactors.

Proceedings of the US/UK Meeting on the Compatibility Problems of Gas-Cooled Reactors Held at Oak Ridge National Laboratory February 24–26, 1960. (TID–7597). U.S. Atomic Energy Commission, 1961. 870 pages (2 books). $8.50. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) The forty papers presented at the US/UK meeting represent the first implementation of the agreement between the United States and the United Kingdom on Gas-Cooled reactors.

Minutes of the Eighth Annual Atomic Energy Commission Welding Conference (TID–7570, Del.). U.S. Atomic Energy Commission, 1960. 407 pages. $5. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A compilation of papers presented at an October 1960 meeting held at Richland, Washington, containing information not previously available. Topics include welding, heat-treating, cutting and inspection experience with stainless steels and aluminum and Hanford experience in nondestructive testing of pressure vessels and process piping.

Proceedings of the University of New Mexico Conference on Organic Scintillation Detectors (TID–7612). U.S. Atomic Energy Commission, 1961, U.S. Government Printing Office. 417 pages. $2.50. This publication reports the results of the conference on organic scintillators, covering the various changes in the field since the 1957 conference on liquid scintillators—held at Northwestern University. Delegates from the United States and eight foreign countries attended this meeting jointly sponsored by the University of New Mexico, the National Science Foundation, and the Office of Special Projects and The Division of Biology and Medicine of the USAEC.

PERIODICALS AND CATALOGS*

The index to Volume 2 of *Nuclear Safety* appeared in the June, 1961 issue. Volumes 4 of the other three journals in this series, *Power Reactor Technology*, *Reactor Fuel Processing*, and *Reactor Core Materials*, were indexed in the September, October, and November, 1961 issues respectively. Cumulative indexes appear in the Number 4 issue of every third volume of each of the four Reviews.

Nuclear Science Abstracts. U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office. Available postpaid on subscription and in single copy at the following prices: Semimonthly issues: Annual subscription rate, $22, domestic; $27.50, foreign; price per single copy, $1.25, domestic; 25 percent

*Available by subscription (domestic, $2 per year; foreign, $2.50 per year), or by individual issue ($0.55) from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

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xtra for foreign mailing. Cumulated—index issues. Annual subscription ate, $15, domestic; $17.50, foreign; price per single copy varies according to he number of pages. Published bimonthly. This bimonthly publication contains abstracts of all current Commission declassified and unclassified reports, f non-Commission reports related to atomic energy, and of articles appearing n both foreign and domestic periodical literature.

roceedings of Technical Meetings. U.S. Atomic Energy Commission, Washington, 1961. No charge. (Available from the U.S. Atomic Energy Commission, Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., on request.) The Commission, in its recognition that meetings and conferences represent a valuable means of exchanging information, sponsors and cosponsors many such meetings. This brochure lists and describes many of the proceedings of meetings in which the Commission or its contractors were sponsors, cosponsors, or major participants.

echnical Books Sponsored by the United States Atomic Energy Commission (3rd Revision). U.S. Atomic Energy Commission, 1961. 55 pages. No charge. (Available from the U.S. Atomic Energy Commission, Office of Technical Information Extension, P.O. Box 62, Oak Ridge, Tenn., on request.) This brochure has been prepared in the third revision to acquaint the Commission and the public with the technical books that have been published and those in preparation to mid-1961. The catalog lists and describes 124 technical books published by the Commission since 1947 and 44 volumes in press or preparation.

DEPOSITORY LIBRARIES

ollections of Commission reports are maintained in the libraries of the rganizations listed below for reference use by the general public. Facilities for aking photocopies are available. The Commission also makes available through ese libraries atomic energy reports of countries other than the United States at are abstracted in *Nuclear Science Abstracts.*

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APPENDIX 7

Film Libraries

The domestic libraries are located at the following Commission offices and cover requests from the following States:

Washington, D.C.	Maryland, Virginia, West Virginia, District of Columbia, Delaware and Canada.
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Aiken, S.C.	Alabama, Florida, North Carolina, South Carolina and Georgia.
Idaho Falls, Idaho	Montana, Utah and Idaho.
Berkeley, Calif.	California and Hawaii.
Grand Junction, Colo.	Colorado, Wyoming, Kansas and Nebraska.
Argonne, Ill.	North Dakota, South Dakota, Missouri, Iowa, Ohio, Indiana, Michigan, Minnesota, Wisconsin and Illinois.
Oak Ridge, Tenn.	Kentucky, Mississippi, Arkansas, Louisiana and Tennessee.
Albuquerque, N. Mex.	Nevada, Arizona, New Mexico, Texas and Oklahoma.
Richland, Wash.	Washington, Oregon and Alaska.

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LICENSE AP

SUM

FACILITIES *

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Test Reactor Licenses
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APPENDIX 8

License Applications Filed and Actions Taken

SUMMARY OF LICENSING ACTIONS

Facilities [a]	Permits and Licenses Issued					Permits and licenses in effect as of Dec. 31, 1961
	Sept. 1, 1954 to Dec. 31, 1957	Jan. 1, 1958 to Dec. 31, 1958	Jan. 1, 1959 to Dec. 31, 1959	Jan. 1, 1960 to Dec. 31, 1960	Jan. 1, 1961 to Dec. 31, 1961	
Reactors						
Construction permits	5	0	0	5	1	7
Construction permit amendments and orders	1	4	5	2	4	----------
Licenses to operate	1	0	1	1	1	4
License amendments, authorizations and orders	1	7	7	7	22	----------
Reactors						
Construction permits	1	2	0	0	0	0
Construction permit amendments and orders	1	0	1	1	0	----------
Licenses to operate	0	0	2	0	1	3
License amendments and authorizations	0	0	3	6	6	----------
arch Reactors						
Construction permits	[b] 20	[c] 11	[d] 15	14	7	[e] 15
Construction permit amendments and orders	5	9	15	12	8	----------
Licenses to operate (including acquire and operate)	28	19	9	11	9	54
License amendments	16	17	34	29	76	----------
tor Exports						
Research Reactor Licenses	16	5	11	3	2	([f])
Test Reactor Licenses	0	2	0	0	1	([f])
Power Reactor Licenses	0	1	1	0	1	([f])
License amendments	6	14	10	14	9	----------
cal Experiment Facilities						
Construction permits	10	4	1	2	0	1
Construction permit amendments and orders	2	2	1	3	2	13 ----------
Licenses to operate	6	5	3	2	0	13
License amendments	1	10	16	14	11	----------
duction Facilities						
Construction permits	0	0	0	0	1	1
Construction permit amendments and orders	0	0	0	0	0	----------
Licenses to operate	0	0	0	0	0	0
Import licenses	0	0	0	1	0	----------
rator licenses	148	215	176	222	[h] 203	[h] 686
rator license amendments and renewals	21	67	81	141	[h] 157	----------
cial Nuclear Material licenses	151	115	73	85	[h] 116	[h] 449
M license amendments and renewals	92	156	194	249	[h] 268	[h] 449
rce Material licenses issued or renewed [g]	4,541	1,303	1,168	1,061	[h] 508	[h] 600
rce Material export licenses	2,456	676	721	696	[h] 221	([f])

[a] Applications to construct and operate are filed simultaneously; conversions from construction permits licenses to operate are made upon satisfactory completion of construction.
[b] Permits authorize construction of 36 reactors and modification of 2 reactors.
[c] Permits authorize construction of 38 reactors.
[d] Permits authorize construction of 13 reactors and modification of 2 reactors.
[e] Permits authorize construction of 24 reactors.
[f] Export licenses terminate upon completion of shipment.
[g] Under amendment to Part 40, Licensing of Source Material, effective Feb. 13, 1961, a license is no longer uired with respect to activities (except export) relating to possession of unrefined and unprocessed ore taining source material. Exports to non-Soviet bloc destinations of up to three pounds of source mate- d any quantity of incandescent gas mantles are authorized by general license under

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FACILITY LICENSE APPLICATIONS [a]

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
POWER REACTORS			
Carolinas Virginia Nuclear Power Associates, Inc., Parr, S.C.	17,000-kilowatt, vertical pressure tube, heavy water moderated and cooled reactor.	July 9, 1959	Construction permit issued May 4, 1960.
Commonwealth Edison Co., Dresden Station, Grundy County, Ill.	180,000-kilowatt, dual cycle, boiling water reactor.	Apr. 1, 1955	Construction permit issued May 4, 1956; 45-day limited license for 1-megawatt (thermal) operation issued September 29, 1959; amended November 4, 1959 to expire December 18, 1959; amended November 18, 1959 for 315-megawatt (thermal) operation after December 10, 1959; amended June 2, 1960 for operation at power levels up to, but not in excess of, an at steady state power level of 630 megawatts (thermal); amended October 14, 1960 for steady state operation at [illegible] megawatts (thermal); reactor shut down in November 1960 due to control rod difficulties; 100-kilowatt operation authorized March 31, 1961; [illegible]-megawatt (thermal) operation authorized May 27, 1961; license amended June 9, 1961 to include revised technical specifications.
Consolidated Edison Co. Westchester County, New York.	163,000-kilowatt, pressurized water (plus 112,000 kw of conventional superheater capacity).	Mar. 22, 1955 (date of application).	Construction permit issued May 4, 1956; amended August 4, 1961 to approve final design of reactor.
Consumers Power Co., Big Rock Point, Charlevoix County, Mich.	75,000-kilowatt, high power density, single cycle, boiling water reactor.	Jan. 18, 1960	Construction permit issued May 31, 1960.
Florida West Coast Nuclear Group, Inc., Polk County, Fla.	50,000-kilowatt, high temperature, gas-cooled, heavy water moderated, pressure tube reactor.	Dec. 10, 1959	Application withdrawn by letter of June 26, 1961
General Electric Co., Alameda County, Calif.	3,000 to 5,000-kilowatt developmental boiling water reactor, designated the Vallecitos Boiling Water Reactor (VBWR).	Jan. 10, 1956 (date of application).	Construction permit issued May 14, 1956; license issued for criticality tests July 29, 1957; for power operation, Aug. 1, 1957; license amendment authorizing operation at power levels to 50,000 kw. (thermal) issued Jan. 30, 1959; amended July 6, 1960 to authorize operation with certain internal modifications and with new fuel arrangements; amended Nov. 5, 1960 to authorize G.E. to make changes within technical specifications described in license amendment provided no unreviewed safety questions is involved; VBWR shut down in Feb. 1961 pending replacement of certain reactor components; resumption of operation authorized Apr. 13, 1961.

5007579

APPLICANT AND LOCATION OF FACILITY	D
...eral Electric Co., Alameda County, Calif.	12,
...thern States Power Co., Sioux Falls, S. Dak.	66,
...ific Gas and Electric Co., Humboldt Bay Power Plant, Eureka, Calif.	50,
...adelphia Electric Co., Peach Bottom, York County, Pa.	40,
...er Reactor Development Co., Lagoona Beach, Mich.	100
...ton Nuclear Experimental Corp., Saxton, Pa.	20,
...kee Atomic Electric Co., Rowe, Mass.	134
...eral Electric Co., Alameda County, Calif.	33,
...tional Aeronautics and Space Administration, Sandusky, Ohio.	60,
...tional Bureau of Standards, Gaithersburg, Md.	10,

[a] Hearing held Dec. 8, 1961 to
[b] Circuit Court Order dated J
...ision Aug. 8, 1960, pending a
...; U.S. Supreme Court anno
...provisional construction perm

Facility License Applications—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
POWER REACTORS—continued			
al Electric Co., Alameda County, Calif.	12,500-kilowatt (thermal) experimental superheat reactor, designated the Vallecitos Experimental Superheat Reactor (VESR).	Feb. 2, 1961	Construction permit issued Aug. 10, 1961.
ern States Power Sioux Falls, S. Dak.	66,000-kilowatt, controlled recirculation boiling water reactor.	Apr. 1, 1959	Construction permit issued May 12, 1960.
Gas and Electric Humboldt Bay Plant, Eureka,	50,000-kilowatt, single cycle boiling water reactor.	Apr. 30, 1959	Construction permit issued Nov. 9, 1960.
elphia Electric Co., Bottom, York nty, Pa.	40,000-kilowatt, helium-cooled, graphite moderated, developmental reactor.	July 25, 1960	Pending.[b]
Reactor Development Co., Lagoona ch, Mich.	100,000-kilowatt fast breeder reactor.	Jan. 7, 1956	Construction permit issued Aug. 4, 1956.[c]
Nuclear Experimental Corp., Saxton,	20,000-kilowatt (thermal) pressurized light water reactor.	July 24, 1959	Provisional operating license issued Nov. 15, 1961.
Atomic Electric Rowe, Mass.	134,000-kilowatt pressurized light water reactor.	July 9, 1956	Construction permit issued Nov. 4, 1957; limited license for 5-megawatt (thermal) operation issued July 9, 1960; amended July 29, 1960 for operation at power levels not in excess of 392 megawatts (thermal); amended June 23, 1961 for full term license authorizing operation at power levels to 485 megawatts (thermal).
TEST REACTORS			
eral Electric Co., Alameda County, Calif.	33,000-kilowatt, pressurized water reactor.	June 14, 1957	Construction permit issued Mar. 11, 1958; licenses issued, for criticality tests Dec. 22, 1958; for test reactor operation Jan. 7, 1959; amended Mar. 11, 1960 to authorize changes in boiling water loop and operation of the loop.
ional Aeronautics and ace Administration, andusky, Ohio.	60,000-kilowatt, pressurized water reactor.	Aug. 20, 1956	Construction permit issued July 21, 1958; provisional license issued Mar. 14, 1961.
onal Bureau of Standards, Gaithersburg, Md.	10,000-kilowatt, heavy water moderated, tank-type reactor.	Feb. 3, 1961	Hearing held Nov. 28, 1961 to consider issuance of a construction permit.

[b] Hearing held Dec. 8, 1961 to consider issuance of a construction permit.

[c] Circuit Court Order dated June 10, 1960, vacated construction permit; Circuit Court granted stay of ssion Aug. 8, 1960, pending appeal by the parties; case argued in U.S. Supreme Court Apr. 26 and 27, 1961. U.S. Supreme Court announced its decision on June 12, 1961, upholding the Commission's issuance provisional construction permit.

5001580

FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
TEST REACTORS—continued			
Westinghouse Electric Corp., Waltz Mill, Pa.	60,000-kilowatt, pressurized water reactor (MTR type).	Mar. 12, 1956	Construction permit issued July 3, 1957; license for 20,000 kw (thermal) operation issued June 19, 1959; amended for 60,000 kw (thermal) operation Jan. 8, 1960; operation suspended by Commission Order June 30, 1960, resumption of operation authorized Sept. 7, 1960.
RESEARCH REACTORS			
Aerojet-General Nucleonics, San Ramon, Calif. (sold to USNPS).	100-milliwatt Model AGN-201 reactor, serial 100.	May 28, 1956	Construction permit issued Aug. 16, 1956; license issued Oct. 19, 1956.
Aerojet-General Nucleonics, San Ramon, Calif. (serials 101 and 102 sold to other licensees).	Two 100-milliwatt and one 5-watt (later amended to 20-watt) Model AGN-201 and AGN-201M reactors, serials 101, 102 and 103.	Sept. 11, 1956	Construction permit issued Feb. 22, 1957; licenses issued Feb. 25, 1957, Mar. 14, 1957 and Mar. 29, 1957 (amended for 20-watt operation Aug. 22, 1958 for 103).
Aerojet-General Nucleonics, San Ramon, Calif.	Four 100-milliwatt and one 5-watt Model AGN-201 and AGN-201M reactors, serials 104 through 108.	Nov. 28, 1956	Construction permit issued July 8, 1957; two licenses issued July 10, 1957; licenses also issued July 31, 1957, Aug. 23, 1957 and Sept. 20, 1957.
Aerojet-General Nucleonics, San Ramon, Calif. (for sale to licensees).	Twelve 100-milliwatt Model AGN-201 reactors, serials 109 through 120.	Feb. 12, 1957	Construction permit issued July 8, 1957; six licenses issued Aug. 23, 1957, Oct. 28, 1957, Jan. 22, 1958, May 16, 1958, June 2, 1958 and June 30, 1958. Application covering construction of remaining six reactors withdrawn by letter of Sept. 16, 1960.
Aerojet-General Nucleonics, San Ramon, Calif. (reactor later exported).	One 1-watt pool-type Model AGN-211 reactor, serial 100.	Nov. 12, 1957	Construction permit issued Jan. 24, 1958; license issued Feb. 12, 1958.
Aerojet-General Nucleonics, San Ramon, Calif. (for sale to licensees).	Fifteen 100-milliwatt Model AGN-201 reactors, serials 126 through 140.	Dec. 2, 1957	Construction permit issued Feb. 20, 1958. Ten reactors (serials 131 through 140) withdrawn from application by letter Sept. 16, 1960.
Do	Five 5-watt (later amended to 20-watt) Model AGN-201 reactors, serials 121 through 125.	Dec. 3, 1957	Construction permit issued Feb. 20, 1958; amendment increasing operating level to 20 watts issued Nov. 14, 1958. Application withdrawn by letter Sept. 16, 1960.
Do	Ten 15-watt (later amended to 100-watt for 3 reactors) Model AGN-211 reactors, serials 101 through 110.	Apr. 14, 1958	Construction permit issued Aug. 6, 1958; amended Mar. 4, 1959 to increase operating level to 100 watts for serials 103, 104 and 105. Two reactors (serials 106 and 105) withdrawn from application by letter Sept. 16, 1960.

5007581

Facility License Applications—Continued

...ICANT AND LOCATION ...OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
RESEARCH REACTORS—continued			
...team Radiator & ...ndard Sanitary Corp., ...ountain View, Calif.	1-watt (UTR-1) graphite moderated reactor (Argonaut type).	July 12, 1957	Construction permit issued Oct. 31, 1957; license issued May 21, 1958. Reactor dismantled and exported for exhibition in Japan; facility license terminated Feb. 29, 1960.
...o.....	1-watt Exhibition UTR-Model II reactor.	Feb. 2, 1960	Construction permit issued Feb. 29, 1960; license issued Mar. 1, 1960. Reactor dismantled and exported for exhibition in Egypt and Pakistan; facility license terminated Aug. 4, 1960.
...o.....	15-watt Model UTR Argonaut-type reactor.	June 15, 1961	Construction permit issued Aug. 14, 1961. License issued Oct. 4, 1961.
...our Research Foun-...ion, Chicago, Ill.	100-kilowatt water boiler type reactor.	Jan. 7, 1955	Construction permit issued Mar. 28, 1955; license issued June 12, 1956 for 10 kw. operation; amended Jan. 14, 1959 for 100 kw. operation; operations suspended in Oct., 1959; amended license issued Dec. 3, 1959 for 50-kilowatt operation; amended May 1, 1961 for 75-kilowatt operation.
...Babcock & Wilcox ..., Lynchburg, Va.	10-kilowatt pool-type reactor. (Lynchburg Pool Reactor).	Mar. 28, 1958	Construction permit issued Sept. 4, 1958; license issued Sept. 5, 1958 for steady state operations at 10 kilowatts and intermittent operation at power levels to 200 kilowatts; amended May 25, 1961 for operation at power levels to 450 thermal kilowatts.
...gile Memorial Insti-...te, West Jefferson, ...io	1,000-kilowatt pool-type reactor (later amended for 2,000 kw. steady state and 3,000 kw intermittent operation).	May 10, 1955	Construction permit issued Aug. 5, 1955; license issued Aug. 10, 1956 for 1,000 kw. operation; amended Feb. 27, 1959 for continuous operation at 2,000 kw. and intermittent operation at 3,000 kw.
...olic University of ...erica, Washington, ...C.	AGN-201 100-milliwatt reactor, serial 101 (purchased from AGN).	July 10, 1957	License issued Nov. 15, 1957.
...rado State University, ...rt Collins, Colo.	AGN-201 100-milliwatt reactor, serial 109 (purchased from AGN).	July 22, 1957	License issued Sept. 12, 1957.
...ell University, Itha-...N.Y.	10-kilowatt dual core, pool-type reactor (application resubmitted to cover 10-watt pool-type reactor designated the Zero Power Reactor).	Feb. 21, 1958 Jan. 4, 1960	Construction permit issued Nov 21, 1958; amended Apr. 15, 1960 to authorize construction of Zero Power Reactor.
Do.....	10-kilowatt TRIGA reactor.	Jan. 4, 1960	Construction permit issued June 29, 1960.

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FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
RESEARCH REACTORS—continued			
Curtiss-Wright Corp., Quehanna, Pa.	1,000-kilowatt pool-type reactor.	Oct. 29, 1956	Construction permit issued June 20, 1957; license issued Apr. 28, 1958 for 100 kw. operation, amended for continuous operation at power levels to 1,000 kw. June 12, 1959; amended Oct. 10, 1960 authorizing shutdown of reactor for 1-year period, license terminated on transfer of reactor to Penn State University effective Dec. 12, 1960.
Daystrom, Inc., West Caldwell, N.J.	10-kilowatt Argonaut-type reactor.	Dec. 11, 1956	Construction permit issued Oct. 11, 1957.[d]
General Dynamics Corp., San Diego, Calif.	TRIGA reactor, 250-kilowatt steady state, multi-megawatt pulses.	Nov. 19, 1957	Construction permit issued May 2, 1958; license issued May 3, 1958.
Do	1,000-kilowatt FLAIR reactor (redesignated TRIGA Mark F by applicant).	Mar. 9, 1960	Construction permit issued July 1, 1960; license issued July 1, 1960.
General Electric Co., Alameda County, Calif.	30-kilowatt, light water cooled and moderated, graphite reflected reactor.	July 1, 1957	Construction permit issued Oct. 24, 1957; license issued Oct. 31, 1957 (operation suspended from Aug. 31, 1958 to Aug. 18, 1960).
Georgia Institute of Technology, Atlanta, Ga.	1,000-kilowatt, tank-type, heavy water moderated and cooled reactor.	Feb. 3, 1960	Construction permit issued June 13, 1960.
Industrial Reactor Laboratories, Inc., Plainsboro Township, N.J.	5,000-kilowatt pool-type reactor, light water cooled and moderated.	Jan. 12, 1956	Construction permit issued Jan. 22, 1957; license for 100 kw. operation issued Oct. 10, 1958, amended for 5,000 kw. operation June 1, 1959; amended to authorize Columbia University to operate the reactor Oct. 24, 1960.
Iowa State University, Ames, Iowa.	10-kilowatt Argonaut-type reactor (AR&SSC Model UTR-10).	Sept. 8, 1958	Construction permit issued Oct. 12, 1959; license issued Oct. 14, 1959.
Kansas State University of Agriculture and Applied Science, Manhattan, Kans.	100-kilowatt TRIGA Mark II reactor.	Apr. 12, 1961	Construction permit issued Aug. 15, 1961.
Lockheed Aircraft Corp., Dawsonville, Ga.	10-watt pool-type training reactor.	Apr. 18, 1960	Construction permit issued June 13, 1960; license issued July 22, 1960, expired Sept. 1, 1960.[e]
Do	10-megawatt Radiation Effects Reactor.	Oct. 3, 1960	Application withdrawn by letter June 8, 1961.
Massachusetts Institute of Technology, Cambridge, Mass.	1,000-kilowatt heavy water moderated reactor.	Feb. 20, 1956	Construction permit issued May 7, 1956; license issued June 9, 1958; amended June 20, 1961, for operation at power levels to 5 thermal megawatts and to make certain modifications in reactor and operating procedures to accommodate operation at increased power levels.

[d] At applicant's request the construction permit was revoked Feb. 14, 1958, without prejudice to filing of new application at later date.

[e] Lockheed reactor was dismantled and exported to South America for exhibition purposes.

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FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
RESEARCH REACTORS—continued			
ional Aeronautics and ace Administration, ndusky, Ohio.	100-kilowatt, water cooled and moderated, beryllium-water reflected reactor, designated the Mock Up Reactor (MUR).	Mar. 20, 1961	Construction permit issued Aug. 1, 1961.
ional Naval Medical enter, Bethesda, Md.	TRIGA reactor, 100-kilowatt steady state, multi-megawatt pulses.	July 21, 1960	Construction permit issued Nov. 8, 1960.
rth American Aviation, c., Atomics International Division, Canoga ark, Calif.	5-watt solution-type laboratory reactor (Model L-47).	Jan. 24, 1957	Construction permit issued Aug. 2, 1957; license issued Aug. 5, 1957.[1]
Do	10-watt solution-type laboratory reactor (Model L-77).	Jan. 20, 1958	Construction permit issued May 17, 1958; license issued May 17, 1958.
C. State College, aleigh, N.C.	100-kilowatt water boiler type reactor.	June 1, 1955	License issued Oct. 1, 1955.
Do	Modification for 500-watt operation.	Dec. 13, 1956	Construction permit issued Mar. 6, 1957; amended license for 500-watt operation issued May 1, 1957.
Do	Relocation and modification for 100-watt operation.	Nov. 19, 1958	Construction permit issued Mar. 18, 1959; amended license for 100-watt operation issued July 13, 1959.
Do	10-kilowatt, graphite reflected, heterogeneous, water moderated.	July 21, 1958	Construction permit issued Nov. 26, 1958; license issued Mar. 16, 1960.
rthrop Corp., Hawthorne, Calif.	100-kilowatt TRIGA Mark F reactor.	Mai. 24, 1961	Construction permit issued July 20, 1961.
io State University, Columbus, Ohio.	10-kilowatt pool-type, light water moderated, graphite reflected reactor.	Nov. 2, 1959	Construction permit issued Feb. 3, 1960; license issued Feb. 24, 1961.
klahoma State University, Stillwater, Okla.	AGN-201 100-milliwatt reactor, serial 102 (purchased from AGN).	Mar. 20, 1957	License issued Aug. 26, 1957.
rdnance Materials Research Office, Watertown, Mass.	1,000-kilowatt pool-type reactor.	Jan. 15, 1957	Construction permit issued Oct. 2, 1957; license issued June 14, 1960.
regon State University, Corvallis, Oreg.	AGN-201 100-milliwatt reactor, serial 114 (purchased from AGN).	May 5, 1958	License issued Nov. 13, 1958.
ennsylvania State University, University Park, Pa.	100-kilowatt pool-type reactor.	May 9, 1955	License issued July 8, 1955; amended for 200-kw-operation May 13, 1960.
ennsylvania State University, Quehanna, Pa.	Curtiss-Wright 4,000-kilowatt pool-type reactor.	Oct. 4, 1960	License authorizing possession only issued Dec. 12, 1960.[2]
urdue University, West Lafayette, Ind.	1-kilowatt, pool-type reactor	Feb. 1, 1961	Construction permit issued Aug. 7, 1961.

[1] The Model L-47 was dismantled by owner, North American Aviation, Inc., and license was terminated at licensee's request on June 30, 1958.

[2] The Curtiss-Wright reactor (built and previously operated by Curtiss-Wright Corp.) is a gift from Curtiss-Wright to Pennsylvania State University. Penn State requests a license for possession only at the

FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
RESEARCH REACTORS—continued			
William M. Rice University, Houston, Tex.	AGN-211 15-watt, pool-type reactor, serial 101 (purchased from AGN).	Aug. 4, 1958	License issued Jan. 8, 1959
Stanford University, Stanford, Calif.	10-kilowatt pool-type, light water moderated and reflected reactor.	June 15, 1959	Construction permit issued Nov. 20, 1959; license issued Dec. 4, 1959.
Texas A. & M. College System, College Station, Tex.	AGN-201 100-milliwatt reactor, serial 106 (purchased from AGN).	Mar. 25, 1957	License issued Aug. 29, 1957
Do	100-kilowatt pool-type, light water moderated and cooled reactor.	Mar. 17, 1959	License issued Dec. 7, 1961.
Texas Technological College, Lubbock, Tex.	10-kilowatt pool-type, water moderated and cooled reactor.	Feb. 1, 1960	Construction permit issued Aug. 3, 1960.
The Prosperity Company, Inc., Coral Gables, Fla.	Pool-type reactor	Mar. 6, 1956	Incomplete application denied Dec. 20, 1957, without prejudice to filing of new application at later date.
Union Carbide Corp., Sterling Forest, Orange County, N.Y.	5,000-kilowatt pool-type reactor.	Feb. 15, 1957	Construction permit issued Oct. 31, 1957; license issued Sept. 7, 1961.
United Nuclear Corp. (formerly Nuclear Development Corp. of America), Pawling, N.Y.	5-watt heavy water moderated and reflected reactor	Apr. 7, 1958	Construction permit issued Oct. 7, 1958; license issued Oct. 22, 1958; amended July 13, 1960 substituting United Nuclear Corp. as licensee.
U.S. Air Force, Dawsonville, Ga.	10-Megawatt Radiation Effects Reactor.	Oct. 17, 1960	Application withdrawn Apr. 27, 1961.
U.S. Naval Hospital, Bethesda, Md.	AGN-201M 5-watt reactor, serial 105 (purchased from AGN).	Mar. 27, 1957	License issued Sept. 13, 1957
U.S. Naval Postgraduate School, Monterey, Calif.	AGN-201 100-milliwatt reactor, serial 100 (purchased from AGN).	Nov. 28, 1956	License issued Apr. 29, 1957
U.S. Naval Research Laboratory, Washington, D.C.	100-kilowatt pool-type reactor.	Apr. 5, 1955	Construction permit issued Apr. 29, 1955; license issued Sept. 14, 1956.
Do	Modification for 1,000-kilowatt operation with forced convection cooling.	July 2, 1959	Construction permit issued Nov. 20, 1959; amended license issued May 31, 1961, authorizing operation of NRL reactor at power levels to 1,000 thermal kilowatts.
University of Akron, Akron, Ohio.	AGN-201 100-milliwatt reactor, serial 104 (purchased from AGN).	Apr. 5, 1957	License issued Sept. 5, 1957.
University of Arizona, Tucson, Ariz.	10-kilowatt tank-type reactor (General Atomic TRIGA).	July 16, 1958	Construction permit issued November 21, 1958; license issued Dec. 5, 1958.
University of California, Los Angeles, Calif.	10-kilowatt Argonaut-type reactor.	July 2, 1959	Construction permit issued Nov. 16, 1959; license issued Oct. 4, 1960, for 10-watt operation; amended Feb. 23, 1961 for 10-kilowatt operation.
University of California, Berkeley, Calif.	AGN-201 100-milliwatt reactor, serial 112 (purchased from AGN).	Aug. 26, 1957	License issued Nov. 19, 1957.

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Facility License Applications—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
RESEARCH REACTORS—continued			
ersity of Delaware, ewark, Del.	AGN-201 100-milliwatt reactor, serial 113.	Mar. 21, 1958	License issued July 3, 1958.
ersity of Florida, ainesville, Fla.	10-kilowatt Argonaut-type reactor.	Aug. 23, 1957	Construction permit issued Dec. 23, 1957; license issued May 21, 1959.
ersity of Illinois, Urbana, Ill.	100-kilowatt tank-type reactor (General Atomic TRIGA Mark II).	Nov. 16, 1959	Construction permit issued Apr 5, 1960; license issued Aug. 16, 1960.
ersity of Kansas, awrence, Kans.	10-kilowatt tank-type, light water moderated and cooled reactor.	Aug. 24, 1959	Construction permit issued Apr. 7, 1960; license issued June 23, 1961.
ersity of Maine, ngor, Maine.	AGN-201 100-milliwatt reactor, serial 132 (to be purchased from AGN).	Sept. 16, 1958	Incomplete application denied Jan. 10, 1961, without prejudice to filing of new application at later date.
ersity of Maryland, ollege Park, Md.	10-kilowatt pool-type, light water moderated, graphite reflected reactor.	Apr. 11, 1960	Construction permit issued June 29, 1960; license issued Oct. 14, 1960.
ersity of Michigan, n Arbor, Mich.	1,000-kilowatt pool-type reactor.	Jan. 12, 1955	Construction permit issued Feb. 17, 1955; license issued for 100 kw. operation Sept. 13, 1957; amended for 1,000 kw. operation Aug. 11, 1958.
ersity of Missouri, olumbia, Mo.	10-kilowatt pool-type, light water moderated reactor.	Jan. 29, 1959	License issued Nov. 21, 1961.
ersity of Missouri olumbia, Mo.	5,000-kilowatt, heterogeneous, light water cooled and moderated, pressurized tank reactor.	Mar. 20, 1961	Pending.
ersity of Oklahoma, orman, Okla.	AGN-211 15-watt, pool-type reactor, serial 102 (purchased from AGN).	July 25, 1958	License issued Dec. 29, 1958.
ersity of Utah, Salt ake City, Utah.	AGN-201 100-milliwatt reactor, serial 107 (purchased from AGN).	June 24, 1957	License issued Sept. 12, 1957.
ersity of Virginia, harlottesville, Va.	1,000-kilowatt pool-type reactor.	Mar. 29, 1957	Construction permit issued Sept. 13, 1957; license issued June 24, 1960.
ersity of Washington, eattle, Wash.	10-kilowatt Argonaut-type reactor.	June 15, 1959	Construction permit Oct. 13, 1959; license issued Mar. 31, 1961.
ersity of Wisconsin, adison, Wis.	10-kilowatt pool-type, light water moderated reactor.	Jan. 27, 1960	Construction permit issued June 7, 1960; license issued Nov. 23, 1960.
ersity of Wyoming, aramie, Wyo.	10-watt laboratory reactor (Atomics International Model L-77).	Nov. 14, 1958	Construction permit issued Feb. 24, 1959; license issued Feb. 25, 1959.
erans Administration ospital, Omaha, Nebr.	10-kilowatt tank-type reactor.	Apr. 10, 1959	Construction permit issued June 24, 1959; license issued June 26, 1959.
ginia Polytechnic Institute, Blacksburg, Va.	10-kilowatt Argonaut-type reactor (AR&SSC Model UTR-10).	Feb. 9, 1959	Construction permit issued Nov. 16, 1959; license issued Dec. 18, 1959.
alter Reed Army Institute of Research, Washington, D.C.	50-kilowatt homogeneous solution-type reactor (Atomics International Model L-54).	May 20, 1959	Construction permit issued Jan. 6, 1960.

FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
RESEARCH REACTORS—continued			
Washington State University (formerly State College of Washington) Pullman, Wash.	100-kilowatt pool-type reactor.	June 22, 1956	Construction permit issued [illegible] 8, 1959; license issued [illegible] 1961.
Western New York Nuclear Research Center, Inc., (formerly University of Buffalo), Buffalo, N.Y.	1,000-kilowatt pool-type reactor.	Mar. 11, 1957.	Construction permit issued [illegible] 15, 1959; license issued [illegible] 1961; amended July [illegible] to substitute Western New York Nuclear Research Center, Inc., as licensee.
West Virginia University, Morgantown, W. Va.	AGN-121 75-watt, pool-type reactor, serial 103.	Mar. 30, 1959	Construction permit issued June 19, 1959; license issued July [illegible], 1959.
Worcester Polytechnic Institute, Worcester, Mass.	1-kilowatt pool-type reactor.	May 1, 1959	Construction permit issued Nov. 23, 1959; license issued Dec. [illegible], 1959.
CRITICAL EXPERIMENT FACILITIES			
Alco Products, Inc., Schenectady, N.Y.	Various critical experiments.	Oct. 13, 1958	License issued Mar. 25, 1959.
Allis-Chalmers Manufacturing Co., Greendale, Wis.	Northern States Power Co. critical experiments.	June 16, 1958	Construction permit issued Nov. 13, 1958; license issued Nov. [illegible], 1959.
The Babcock & Wilcox Co., Lynchburg, Va.	Consolidated Edison Company critical experiments and NMSR critical experiments.	Oct. 27, 1955	Construction permit issued Dec. 9, 1955; license issued Mar. [illegible], 1957; amended to authorize additional experiments Jan. [illegible], 1958, May 28, 1958, April [illegible], 1959, October 12, 1959, Dec. [illegible], 1959, Oct. 25, 1960 and Nov. [illegible], 1960.
Do	Critical experiments for Nuclear Merchant Ship Reactor (NMSR) and Spectral Shift Control Reactor (SSCR).	Feb. 1, 1957	Construction permit issued Oct. 2, 1957; license issued Jan. [illegible], 1958; amended to authorize additional experiments May [illegible], 1959; June 25, 1959 and Feb. [illegible], 1961.
Do	Critical experiments for Liquid Metal Fuel Reactor Experiment (LMFRE) and others.	May 20, 1958	Construction permit issued Sept. 24, 1958; license issued Sept. [illegible], 1958; amended to authorize additional experiments Mar. 20, 1961.
Do	Critical experiments for Advanced Test Reactor (ATRCE).	Sept. 15, 1961	Pending.
Battelle Memorial Institute, West Jefferson, Ohio.	Plastic Reactor Facility	Oct. 28, 1955	Construction permit issued Dec. 28, 1955; license (to possess only) issued Jan. 16, [illegible] amended to authorize operation and conduct of specific experiment June 9, 1961.

[b] Facility constructed in 1956 under contract with and for the account of the Atomic Energy Commission License authorizes conduct of private work.

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FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
CRITICAL EXPERIMENT FACILITIES—continued			
ral Dynamics Corpo-, San Diego, Calif.	Critical experiments for General Dynamics research reactors.	Oct. 25, 1956	Construction permit issued June 18, 1957; license issued Aug. 13, 1957; amended for additional experiments Aug. 26, 1957, Feb. 3, 1958, June 26, 1958 and July 18, 1958.[i]
al Electric Co., Ala-a County, Calif.	Critical experiments for Commonwealth Edison reactor and others.	Mar. 27, 1956	Construction permit issued June 29, 1956; license issued Aug. 30, 1957; amended to broaden scope of activities May 29, 1959 and June 3, 1960; amended for additional experiments Oct. 4, 1960 and June 8, 1961.
Do.	Nuclear checkout tests for Spanish Research Reactor.	June 14, 1957	Construction permit issued Sept. 20, 1957; license issued Oct. 16, 1957 (tests completed and license expired May 20, 1958).
heed Aircraft Corp., o Alto, Calif.		June 20, 1956	Construction permit issued Mar. 14, 1957 (expired Sept. 30, 1957).[j]
heed Aircraft Corp., wsonville, Ga.	Various critical experiments.	Oct. 3, 1960	Application withdrawn by letter June 8, 1961.
Martin-Marietta rp., Middle River, d.	Martin Power Reactor (MPR) and Engineering Research and Development Laboratory (ERDL) critical experiments and others.	Oct. 26, 1956	Construction permit issued May 13, 1957; license issued Dec. 6, 1957 for MPR experiments amended for ERDL experiments June 12, 1958; amended for additional experiments Apr. 30, 1959, November 27, 1959, Mar. 8, 1960, May 3, 1960, June 7, 1960, June 21 and June 22, 1961.
Do.	Liquid Fluidized Bed Reactor (LFBR) critical experiments.	Jan. 4, 1960	License issued Dec. 28, 1961.
onal Aeronautics and ace Administration, eveland, Ohio.	Series of critical experiments.	July 8, 1957	Construction permit issued Jan. 22, 1958; license issued Jan. 5, 1959.
n American Aviation, , Canoga Park, Calif.	Critical experiments relating to Advanced Epithermal Thorium Reactor (AETR) program.	Aug. 20, 1959	Construction permit issued Dec. 24, 1959; license issued Oct. 3, 1960.
ear Development Cor ration of America, wling, N.Y.		Mar. 14, 1956	Construction permit issued June 11, 1956; license (to possess only) issued Jan. 22, 1958.[k]
Air Force, Dawson-, Ga.		Oct. 17, 1960	Application withdrawn by letter Apr. 27, 1961.

[i] Facility dismantled and license terminated March 15, 1960 at licensee's request.

[j] Plans to construct facility as originally designed abandoned, per Lockheed's letter dated February 11, 1958.

[k] License terminated at licensee's request on June 22, 1961. All experiments are performed in the Pawling Research Reactor operated by United Nuclear Corporation, formerly Nuclear Development Corporation of America.

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FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
CRITICAL EXPERIMENT FACILITIES—continued			
Westinghouse Electric Corp., Waltz Mill, Pa.	CRX Facility-Yankee critical experiments.	Sept. 21, 1956	Construction permit issued [illegible] 17, 1957; license issued [illegible] kee experiments Nov. [illegible] with amendments for additional experiments June [illegible] and Aug. 22, 1958, license amended for BR-3 experiments Oct. 17, 1958, with amendments for additional experiments [illegible] 12, 1959 and Jan. [illegible] license amended for two-region experiments Dec. 18, 1958, with amendments for additional experiments June 3, 1959 which also includes RFMF experiments; license amended for "Loose Lattice" experiments July 10, 1959.
	Belgian Reactor-3 (BR-3).	Sept. 8, 1958	
	Two-region critical experiments.	Nov. 13, 1958	
	Reactor Fuel Measurement Facility (RFMF) experiments.	Apr. 30, 1959	
	Loose Lattice critical experiments.	May 25, 1959	
Do	CES Facility-Westinghouse Test Reactor critical experiments.	Oct. 24, 1957	Construction permit issued June 14, 1958; license issued June [illegible], 1958, amended for additional experiments Jan. 7, 1959 and Oct. 29, 1959.
Do	LRX Facility-Carolinas Virginia Tube Reactor critical experiments.	Dec. 23, 1959	Construction permit issued Apr. 26, 1960; license issued May [illegible] 1960.
PRODUCTION FACILITIES			
The Decker Corp., Bala Cynwyd, Pa.	Gas Centrifuge Plant	Mar. 29, 1960	Pending—Application incomplete.
The Martin-Marietta Corp., Quehanna, Pa.	Chemical Separation Facility.	Jan. 25, 1961	Construction permit issued May 1, 1961.
Thor-Westcliffe Development, Inc., Pittsburg, Kans.	Multi-stage gas centrifuge production facility for the separation of uranium isotopes.	July 14, 1959	Pending—Application incomplete.
EXPORT LICENSES			
Aerojet-General Nucleonics, San Ramon, Calif.	100-milliwatt AGN-201 reactor, serial 110, for export to Instituto di Fisica, Facolta D'Ingegneria, University of Palermo, Palermo, Sicily.	Apr. 21, 1958	License issued Jan. 7, 1959
Allis-Chalmers Manufacturing Co., Milwaukee, Wis. (formerly ACF Industries).	5,000-kilowatt tank-type heavy water moderated and cooled research reactor for export to Comitato Nazionale per le Ricerche Nucleari, Milan, Italy.	Dec. 12, 1956	License issued May 16, 1957

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Facility License Applications—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
EXPORT LICENSES—continued			
Allis-Chalmers Manufacturing Co., Milwaukee, Wis.—Continued	20,000-kilowatt tank-type materials testing reactor for export to Reactor Centrum Nederland, Pettin, The Netherlands.	Apr. 23, 1957	License issued Jan. 17, 1958.
Do	30,000-kilowatt tank-type materials testing reactor for export to Aktiebolaget Atomenergi of Sweden, Tystberga, Sweden.	June 18, 1957	License issued May 14, 1958.
Do	20,000-kilowatt tank-type light water cooled and moderated test reactor for export to South African Atomic Energy Board, Pelindaba, South Africa.	Jan. 12, 1961	License issued June 14, 1961.
American Intercontinental Trade & Service Co., New York, N.Y.	43,000-kilowatt pressurized light water power reactor for export to Centre d'Etudes de l'Energie Nucleaire, Brussels, Belgium.	July 8, 1958	License issued Nov. 6, 1958.
American Machine & Foundry Co., New York, N.Y.	10-kilowatt light water moderated research reactor for export to Ministry of Education, Kingdom of the Netherlands, Amsterdam, The Netherlands.	Sept. 27, 1956	License issued Feb. 1, 1957.
Do	1,000-kilowatt pool-type research reactor for export to Laboratorium fur Technische Physik der Technischen Hochschule, Munich, Germany.	July 2, 1956	License issued Mar. 15, 1957.
Do	1,000-kilowatt pool-type research reactor for export to Hamilton College, McMaster University, Hamilton, Canada.	May 17, 1957	License issued Aug. 27, 1957.
Do	1,000-kilowatt pool-type research reactor for export to Junta de Energia Nuclear, Lisbon, Portugal.	July 22, 1957	License issued Sept. 13, 1957.
Do	1,000-kilowatt pool-type research reactor for export to Greek Atomic Energy Commission, Athens, Greece.	May 7, 1957	License issued Sept. 25, 1957.

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FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
EXPORT LICENSES—continued			
American Machine & Foundry Co., New York, N.Y.	1,000-kilowatt pool-type research reactor for export to Societa Ricerche Impianti Nucleari, Milan, Italy.	July 3, 1957	License issued Dec. 6, 1957.
Do	1,000-kilowatt pool-type research reactor for export to Commissariat a L'Energie Atomique, Tel Aviv, Israel.	Apr. 11, 1958	License issued June 12, 1958.
Do	5,000-kilowatt tank-type research reactor for export to Osterreichische Studiengesellschaft m.b.h., Seibersdorf, Austria.	June 19, 1958	License issued Sept. 3, 1958.
Do	5,000-kilowatt pool-type research reactor for export to the University of Teheran, Teheran, Iran.	Apr. 20, 1959	License issued Aug. 5, 1959.
Do	1,000-kilowatt pool-type research reactor for export to Turkish Atomic Energy Commission, Istanbul, Turkey.	June 10, 1959	License issued Sept. 4, 1959.
Do	5,000-kilowatt pool-type, light water moderated and cooled research reactor.	Aug. 21, 1961	Pending.
American Radiator & Standarn Sanitary Corporation, Mountain View, Calif.	10-kilowatt Model UTR-10 research reactor for export to Australian Atomic Energy Research Establishment, Lucas Heights, New South Wales, Australia.	June 6, 1960	License issued Sept. 12, 1960.
Do	0.1 watt water-moderated, graphite-reflected research reactor for export to Kinki University, Fuse, Osaka, Japan.	Oct. 7, 1960	License issued Apr. 18, 1961.
The Babcock & Wilcox Co., New York, N.Y.	5,000-kilowatt pool-type research reactor for export to Conselho Nacional de Pesquisas do Brasil, for Comissao de Energia Atomica, Sao Paulo, Brazil.	Oct. 5, 1956	License issued Jan. 22, 1957.
Do	5,000-kilowatt pool-type research reactor for export to Society for the Utilization of Nuclear Energy in Shipbuilding & Navigation, Inc., Hamburg, Germany.	Feb. 1, 1957	License issued June 10, 1957.

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APPLICANT AND LOCATION OF FACILITY
Curtiss-Wright Corp., New York, N.Y.
Foster-Wheeler Corp., New York, N.Y.
General Dynamics Corp., San Diego, Calif.
Do
Do
Do
Do
Do
Do

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Facility License Applications—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
EXPORT LICENSES—continued			
Curtiss-Wright Corp., New York, N.Y.	1,000-kilowatt pool-type research reactor for export to Thai Atomic Energy Commission for Peace, Bangkok, Thailand.	June 12, 1959	License issued Nov. 5, 1959.
Babcock-Wheeler Corp., New York, N.Y.	5,000-kilowatt tank-type research reactor for export to Danish Atomic Energy Commission, Christiansborg, Copenhagen, Denmark.	Jan. 25, 1957	License issued Apr. 4, 1957.
General Dynamics Corp., San Diego, Calif.	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Comitato Nazionale per le Ricerche Nucleari, Rome, Italy.	Nov. 7, 1958	License issued Jan. 8, 1959.
Do	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Government of the Republic of Korea, Seoul, Korea.	Mar. 4, 1959	License issued May 21, 1959.
Do	30-killowatt TRIGA research reactor for export to Escola de Engenharia da Universidade de Minas Ferais, Belo Horizonte, Brazil.	Mar. 4, 1959	License issued Aug. 3, 1959.
Do	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Republic of Austria, Federal Ministry of Education, Vienna, Austria.	Mar. 4, 1959	License issued Nov. 24, 1959.
Do	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Office of Atomic Energy of the Republic of Viet Nam, Dalat, Viet Nam.	June 16, 1959	License issued Oct. 20, 1959.
Do	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Musashi College of Technology, Toyko, Japan.	Feb. 19, 1960	License issued July 8, 1960.
Do	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Rikkyo University, Tokyo, Japan.	Feb. 19, 1960	License issued July 8, 1960.

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FACILITY LICENSE APPLICATIONS—Continued

APPLICANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
EXPORT LICENSES—continued			
General Dynamics Corp., San Diego, Calif.	100-kilowatt tank-type research reactor (TRIGA Mark II) for export to Kauppa-Ja Teollisuusministerio, for installation in the Teknillinen Korkeakoulu at Otaniemi, Finland.	Jan. 13, 1961	License issued Apr. 5, 1961
General Electric Co., New York, N.Y.	,000-kilowatt pool-type research reactor for export to Junta de Energia Nuclear, Madrid, Spain.	May 22, 1957	License issued July 29, 1957
Do	3,000-kilowatt pool-type research reactor for export to Instituto Venezolano de Investigaciones Cientificas, Caracas, Venezuela.	Oct. 3, 1957	License issued Jan. 16, 1958
Do	1,000-kilowatt pool-type research reactor for export to National Tsing-Hua University, Taipei, Taiwan, Republic of China.	Apr. 4, 1958	License issued June 5, 1958
Do	15,000-kilowatt (electrical) boiling water type power reactor for export to Allgemeine Elektricitata-Gesellschaft AG, Frankfurt, Germany.	June 9, 1959	License issued Sept. 30, 1959
Do	1,000-kilowatt pool-type research reactor for export to the Philippine Atomic Energy Commission, Manila, Republic of the Philippines.	July 7, 1959	License issued Nov. 16, 1959
Do	150,000-kilowatt (electrical) boiling water type power reactor for export to Societa Electtronucleare Nazionale (SENN), Rome, Italy.	Apr. 5, 1960	License issued Aug. 16, 1961
Intercontinental Chemical Corp., New York, N.Y.	50-kilowatt solution-type research reactor (Atomics International Model L-54) for export to Farbwerke Hoechst AG, Frankfurt, Germany.	Apr. 1, 1957	License issued June 11, 1957
Loretz & Co., Los Angeles, Calif.	500-watt solution-type research reactor (Atomics International Model L-55) for export to the Danish Atomic Energy Commission, Christiansborg, Copenhagen, Denmark.	Jan. 17, 1957	License issued Apr. 4, 1957

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Facility License Applications—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
EXPORT LICENSES—continued			
James Loudon & Co., Inc., Los Angeles, Calif.	50-kilowatt solution-type research reactor (Atomics International Model L-54) for export to the Senate of the Land Berlin, Berlin, Germany.	Mar. 28, 1957	License issued Sept. 7, 1957.
Luigi Serra, Inc., New York, N.Y.	5,000-kilowatt pool-type research reactor for export to Centro Autonomo Militare Energia Nucleare (C.A.M.E.N.), Accademia Navale, Livorno, Italy.	Sept. 3, 1959	License issued Dec. 17, 1959.
Marubeni-Iida Co. (N.Y.), Inc., New York, N.Y.	50-kilowatt solution-type research reactor (Atomics International Model L-54) for export to The Japan Atomic Energy Research Institute, Tokyo, Japan.	Sept. 13, 1956	License issued Nov. 2, 1956.
Mitsubishi International Corp., New York, N.Y.	10,000-kilowatt tank-type research reactor for export to The Japan Atomic Energy Research Institute, Tokyo, Japan.	Aug. 12, 1957	License issued Oct. 11, 1957.
S.A. Innocente Mangili Adriatica, Inc., New York, N.Y.	50-kilowatt solution-type research reactor (Atomics International Model L-54) for export to Politecnico Di Milano, Milan, Italy.	June 2, 1958	License issued Aug. 13, 1958.

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APPENDIX 9

Access Permits

NUMBER OF PERMITTEES HAVING ACCESS TO SECRET RESTRICTED DATA BY CATEGORIES

	Nov. 30, 1960	Nov. 30, 1961
Isotope Separation—Gas Centrifuge Method	0	[illegible]
Nuclear Technology	693	[illegible]
Plutonium Production	12	[illegible]

NOTE.—As of November 30, 1961, 415 permittees had 500 employees or less, while 420 had over [illegible] employees. As of November 30, 1960, permittees with 500 or less employees numbered 540, while 492 had over 500 employees.

ACCESS PERMIT HOLDERS BY GEOGRAPHIC AREAS

	Nov. 30, 1960	Nov. 30, 1961
New England	109	[illegible]
Middle Atlantic	357	[illegible]
East North Central	192	[illegible]
West North Central	50	[illegible]
South Atlantic	104	[illegible]
East South Central	23	[illegible]
West South Central	41	[illegible]
Mountain	31	[illegible]
Pacific	121	[illegible]
Hawaii, Alaska, and Puerto Rico	4	[illegible]
Total	1,032	[illegible]

NOTE.—Standard Department of Commerce Areas.

ACCESS PERMIT

[illegible]eries (Nuclear)	[illegible]
[illegible]nical Processing and Equi[illegible]	[illegible]
[illegible]ponents (except Reactor C[illegible]	[illegible]
[illegible]ultants	[illegible]
[illegible]rolled Thermonuclear Fiel[illegible]	[illegible]
[illegible]sign and Construction of Ato[illegible]	[illegible]
[illegible]tronic Systems	[illegible]
[illegible] Element Fabrication	[illegible]
[illegible]eral Nuclear Research and I[illegible]	[illegible]
[illegible]rmation Services	[illegible]
[illegible]ruments	[illegible]
[illegible]rance Evaluation	[illegible]
[illegible]stment and Banking	[illegible]
[illegible]ope Production and Utilizati[illegible]	[illegible]
[illegible]al Assistance and Accountin[illegible]	[illegible]
[illegible]chinery	[illegible]
[illegible] Refining and Production of [illegible]	[illegible]
[illegible]ation Hazards and Effects	[illegible]
[illegible]oactive Waste	[illegible]
[illegible]ctor-Central Station	[illegible]
[illegible]ctor-Components	[illegible]
[illegible]ctor-Heating	[illegible]
[illegible]ctor-Other	[illegible]
[illegible]ctor-Propulsion	[illegible]
[illegible]ctor-Research	[illegible]
[illegible]ld Materials	[illegible]
[illegible]al Materials	[illegible]
[illegible]veys for Potential Use or Nee[illegible]	[illegible]
[illegible]ning and Education	[illegible]
[illegible]nsportation and Storage	[illegible]
[illegible]apons and Components	[illegible]
[illegible]ers (not elsewhere classifiable)	[illegible]
Total	[illegible]

[illegible]OTE.—These figures include p[illegible]er than the number of permit

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ACCESS PERMIT HOLDERS BY PRINCIPAL FIELDS OF INTEREST

	Nov. 30, 1960	Nov. 30, 1961
...eries (Nuclear)	0	0
...mical Processing and Equipment	41	36
...ponents (except Reactor Components)	49	38
...sultants	145	102
...trolled Thermonuclear Field	22	17
...gn and Construction of Atomic Energy Facilities	67	53
...ronic Systems	9	8
... Element Fabrication	21	21
...eral Nuclear Research and Development	53	46
...mation Services	25	27
...uments	61	49
...ance Evaluation	73	63
...stment and Banking	8	5
...ope Production and Utilization	52	44
...al Assistance and Accounting	25	24
...chinery	11	10
... Refining and Production of Feed Materials	43	34
...iation Hazards and Effects	35	31
...oactive Waste	29	23
...ctor-Central Station	146	130
...ctor-Components	31	30
...ctor-Heating	4	4
...ctor-Other	20	19
...ctor-Propulsion	35	35
...ctor-Research	14	11
...d Materials	13	11
...tal Materials	71	60
...eys for Potential Use or Need	16	9
...ning and Education	12	9
...sportation and Storage	6	3
...pons and Components	1	0
...ers (not elsewhere classifiable)	7	6
Total	1,145	958

...TE.—These figures include permit holders with more than one field of interest, resulting in a total ...er than the number of permittees.

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BUSINESS OR OCCUPATION OF ACCESS PERMIT HOLDERS

	Nov. 30, 1960	Nov. 30, 1961
Aircraft and/or Components	30	[illegible]
Beverage Industry	1	[illegible]
Chemical-General	56	[illegible]
Chemical-Pharmaceutical	3	[illegible]
Chemical-Processing Equipment	12	[illegible]
Coal Industry	2	[illegible]
Communications	1	[illegible]
Consultants	66	[illegible]
Educational Institutions	27	[illegible]
Electronic Industry	19	[illegible]
Engineering-Construction	32	[illegible]
Engineering-Consulting	48	[illegible]
Engineering-Design	54	[illegible]
Federal, State, and City Governments or Departments	32	[illegible]
Financial Organizations	8	[illegible]
Food Companies	1	[illegible]
Information Services	14	[illegible]
Instrument Manufacturer	47	[illegible]
Insurance Companies	70	[illegible]
Lawyers and Public Accountants	26	[illegible]
Machinery-General	27	[illegible]
Machinery-Special	21	[illegible]
Metal Products Manufacture	101	[illegible]
Mining and Refining	38	[illegible]
Motor Vehicles and/or Components	5	[illegible]
Paper and Pulp Companies	1	[illegible]
Petroleum and Petroleum Products	16	[illegible]
Printing and Publishing	6	[illegible]
Professors, Teachers, and Scientists	29	[illegible]
Railroads and Railway Equipment	11	[illegible]
Research-General	40	[illegible]
Research-Medical	4	[illegible]
Rubber and Rubber Products	5	[illegible]
Scrap and Waste Disposal	5	[illegible]
Shipbuilding and/or Components	18	[illegible]
Special Carriers and Warehousing	3	[illegible]
Stone, Clay, and Glass Products	12	[illegible]
Tobacco and Tobacco Products	0	[illegible]
Unions, Trade Associations, Chambers of Commerce, and Manufacturers' Representatives	15	[illegible]
Utilities	136	[illegible]
Weapons, Explosives, and Propellants	3	[illegible]
Others (not elsewhere classifiable)	6	[illegible]
Total [1]	1,051	[illegible]

[1] Some Permittees have been classified in more than one category.

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APPENDIX 10

NUCLEAR REACTORS BUILT, BEING BUILT OR PLANNED IN THE UNITED STATES AS OF DECEMBER 31, 1961

This compilation contains information about facilities built, being built, or planned in the United States as of December 31, 1961, which are capable of sustaining a nuclear chain reaction. Certain projects relating to military systems are not listed in detail because of their classified nature.

Information is presented in five parts, each of which is categorized by primary function or purpose. The first four categories, namely, civilian, military, production, and export, as well as such categories as power, propulsion, and process heat, are self-explanatory. The major parts of the tabulation follow:

I. Civilian Reactors (Domestic)
II. Military Reactors
III. Production Reactors
IV. Reactors for Export
V. Critical Assembly Facilities

Various classes of reactors within these categories are defined as follows:

Reactor Experiment. A reactor in the research and development program, usually producing less than 10 Mw(t), designed for the limited purpose of testing the technical feasibility of a reactor concept or some unique reactor feature or piece of equipment. A reactor experiment is built with the intention of making changes in fueling structure, associated components, or other components of the reactors. (Part I, Sec. 2A.2)

Experimental Reactor. A relatively complete reactor plant designed, engineered, constructed, and operated to provide the technical basis for the design of a large-scale nuclear power plant. Design flexibility permits changes to prove-out different aspects of reactor technology. Electricity or power generation may or may not be included as part of the plant. (Part I, Sec. 2A.1)

Prototype Reactor Plant. A nuclear power plant of any size designed, constructed, and operated principally for the purpose of proving-out economical and technical aspects of a future commercial nuclear power plant of the same type. The generation of significant quantities of electricity, mechanical power, or process heat is usually a function of such a plant. Prototypes [40 to 50 Mw(e) and larger] for large central-station plants are listed in Part I, Sec. 1A.1. Prototypes for small utility stations [smaller than 40 Mw(e)] are listed in Part I, Sec. 1A.2.

Commercial Reactor Plant. A nuclear facility constructed and operated under license issued under Section 103 of the Atomic Energy Act of 1954 and capable of producing steam for the generation of electricity, propulsion, and space or process heat applications at costs as low as a nonnuclear plant built at the same time. (No reactors presently in the category.)

General Irradiation Test Reactor. This general-test-reactor category includes only those reactors having (1) a thermal output of 10,000 kw or more; (2) test loops or experimental facilities within, or in proximity to, the core; and (3) the use of nuclear radiation for testing the life or performance of reactor components as the major function. (Part I, Secs. 3A.1 and 3A.2, and Part IV, Sec. 2A)

Other Test Reactors. A reactor which is, in general, an integral part of a test performance, which has kinetic or short-duration high-power excursion, or which is designed for special testing purposes. (Part I, Sec. 3B, and Part II, Sec. 3A)

Research Reactor. Any reactor whose nuclear radiations are used primarily as a research tool for basic or applied research regardless of operating power level. May include facilities for testing reactor materials. (Part I, Sec. 3C; Part II, Sec. 3B; and Part IV, Sec. 2B)

Teaching Reactor. Any reactor operated for the primary purpose of training in the operation and utilization of reactors and for instruction in reactor theory and performance. Thermal power level is usually limited to 10 kw. (Part I, Sec. 3D, and Part IV, Sec. 2C)

Critical Facility. A reactor capable of sustaining a nuclear chain reaction and designed to test at extremely low power (a few watts) a critical mass, neutron-flux distribution, and other characteristics of flexible arrangement of nuclear fuel, materials of construction, coolant, and other reactor components. Fluid critical facilities are used to explore the critical masses of various concentrations of solutions in differing geometries. Metal critical assemblies are used to investigate the variations in heterogeneous cores. The tabulation of these facilities in Part V excludes those that have been dismantled.

The abbreviated listings in the principal-contractor column refer to the technical organization assigned primary responsibility for design and/or fabrication of the reactor system. The spelled-out forms for those abbreviations, as well as those for designers, shipbuilders, and facility operators, are given in the table on page 459.

Start-up dates refer to the year of first criticality. Estimated dates for projects not yet in service, based on the best available information, are included. The dates for non-Commission projects are estimates announced by the sponsoring organizations.

Reactors are listed as being *operable* under the following circumstances:

1. Federal Government reactors—when criticality is achieved.
2. Non-Federal Government reactors in the United States—when an operating license is issued by the Commission.
3. Reactors for foreign locations—when criticality is achieved.

Reactors are listed as *being built* under the following circumstances:

1. Federal Government reactors—when ground is broken, components are ordered, or construction contract is awarded.
2. Non-Federal Government reactors in the United States—when the construction permit is issued by the Commission.
3. Reactors for foreign locations—when an application for an export license is received by the Commission or when reliable information is received relating to the fabrication of reactor components.

Reactors are listed as being *planned* under the following circumstances:

1. Federal Government reactors—when public announcement is made or appropriately authorized by the agency involved as a project planned for construction.
2. Non-Federal Government reactors in the United States—when license application is received by the Commission or a public announcement that includes principal contractor and reactor type is made.
3. Reactors for foreign locations—when public announcement that includes principal contractor and reactor type is made or when the Commission receives information that a U.S. reactor manufacturer is proceeding with preconstruction design and development on the basis of a letter of intent.

The Statistical Summary on page 460 excludes critical facilities. All other categories are summarized. Dismantled reactors in these categories are included since such facilities have made significant contributions to reactor technology.

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ockheed
Mare Island
Martin
Maxon
Met. Lab
ASA

ST OF CONTRACTORS, DESIGNERS, SHIPBUILDERS, AND FACILITY OPERATORS FOR WHICH ABBREVIATIONS APPEAR IN TABLES

.....	Allis-Chalmers Mfg. Co.
..F.....	ACF Industries, Inc. (Absorbed by AC)
.....	Aerojet-General Corp.
..N.....	Aerojet-General Nucleonics, a Subsidiary of Aerojet-General Corp.
.....	Atomics International, a Division of North American Aviation, Inc.
..o.....	Alco Products, Inc.
..MF.....	AMF Atomics, Inc., a Division of American Machine & Foundry Co.
..NL.....	Argonne National Laboratory, operated by the University of Chicago
..PD.....	Aircraft Nuclear Propulsion Department, General Electric Co.
..SS.....	American Radiator & Standard Sanitary Corp.
..C.....	Bendix Aviation Corp.
..blehem.....	Shipbuilding Division, Bethlehem Steel Co.
..w-Knox.....	Blaw-Knox Co.
..NL.....	Brookhaven National Laboratory, operated by Associated Universities, Inc.
..W.....	Babcock & Wilcox Co.
.....	Combustion Engineering, Inc.
.....	Clinton Laboratory of the Manhattan Engineering District
..vair.....	Convair Division, General Dynamics Corp.
..ok.....	Nucledyne Co., a Division of Cook Electric Co.
..W.....	Curtiss-Wright Corp.
..ystrom.....	Daystrom, Inc.
..Pont.....	E. I. du Pont de Nemours & Co., Inc.
..asco.....	Ebasco Services, Inc.
..c. Boat.....	Electric Boat Division, General Dynamics Corp.
..W.....	Foster Wheeler Corp.
..DC.....	General Atomic Division, General Dynamics Corp.
..E.....	General Electric Co.
..NEC.....	General Nuclear Engineering Corp., a Subsidiary of Combustion Engineering, Inc.
..KF.....	H. K. Ferguson Co.
..ghes.....	Hughes Aircraft Co.
.....	Internuclear Co.
..galls.....	Ingalls Shipbuilding Corp.
..APL.....	Knolls Atomic Power Laboratory, operated by General Electric Co.
..E.....	Kaiser Engineers, a Division of Henry J. Kaiser Co.
..ASL.....	Los Alamos Scientific Laboratory, operated by the University of California
..ckheed.....	Lockheed Aircraft Corp.
..are Island.....	Mare Island Naval Shipyard
..artin.....	Martin Co.
..axon.....	Maxon Construction Co.
..et. Lab.....	Metallurgical Laboratory of the Manhattan Engineering District

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Newport News	Newport News Shipbuilding & Dry Dock Co.
NRL	Naval Research Laboratory
NYSC	New York Shipbuilding Corp.
ORNL	Oak Ridge National Laboratory, operated by Union Carbide Nuclear Co., a Division of Union Carbide Corp.
Portsmouth	Portsmouth Naval Shipyard
PPC	Phillips Petroleum Co.
P&W	Pratt & Whitney Aircraft Division, United Aircraft Corp.
Sandia	Sandia Laboratory, operated by Sandia Corp., a Subsidiary of Western Electric Co.
UCLRL	University of California Lawrence Radiation Laboratory
UNC	United Nuclear Corp. Development Division
West	Westinghouse Electric Corp.

STATISTICAL SUMMARY

	Operated, later dismantled	Operable	Being built	Planned
I. CIVILIAN REACTORS:				
1. Power-reactor prototypes:				
A.1. Prototypes, large central-station plants		3	6	4
A.2. Prototypes, small central-station plants			4	
B. Prototypes, maritime propulsion (seagoing)		1		
2. Experimental power reactor and reactor experiments:				
A.1. Experimental power reactors (generate electricity)		3	4	
A.2. Power-reactor experiments (token electrical production, if any)	6	4	6	2
B. Space propulsion experiments (ROVER)	4		(*)	(*
C. Auxiliary power for space (SNAP)				3
3. Test, research, and teaching reactors:				
A.1. General irradiation test (Government owned)		3	1	
A.2. General irradiation test (privately owned)		2		
B. Special test		8	2	
C. Research	4	32	10	1
D. Teaching	3	37	13	2
II. MILITARY REACTORS:				
1. Defense power-reactor applications:				
A. Electric-power reactors, remote installations		2	2	1
B. Propulsion reactors (naval)	1	37	39	
2. Developmental power reactors:				
A.1. Electric-power-reactor experiments and prototypes	1	2	1	1
A.2. Special purpose (auxiliary power for space)	1	1		2
B.1. Naval propulsion reactor prototypes	1	5	2	
B.2. Aircraft-propulsion reactor experiments	2	2		
B.3. Missile-propulsion reactor experiments	1		1	
3. Test and research:				
A. Testing reactors	1	6	2	
B. Research reactors		6	2	1
III. PRODUCTION REACTORS:				
1. Materials production		13	1	
2. Process development		6		
IV. REACTORS FOR EXPORT:				
1. Power reactors:				
A. Central-station electric power		1	4	2
B. Propulsion			1	
2. Test, research, and teaching reactors:				
A. General irradiation test		3		2
B. Research		17	9	2
C. Teaching		14	3	2

* ... to be tested in 1962

A. CENTRAL STATION ELECTRIC

A.1. Large-Plant Prototypes

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up
OPERABLE						

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A. CENTRAL STATION ELECTRIC

A.1. Large-Plant Prototypes

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up
OPERABLE						
Shippingport Atomic Power Station[2] (AEC and Duquesne Light Co.).	Shippingport, Pa	West	Pressurized water	60,000	231,000	1957
Dresden Nuclear Power Station (Commonwealth Edison Co.).	Morris, Ill	GE	Boiling water	185,000	629,000	1959
Yankee Nuclear Power Station[3] (Yankee Atomic Electric Co.).	Rowe, Mass	West	Pressurized water	141,000	485,000	1960
BEING BUILT						
Indian Point Unit No. 1 (Consolidated Edison Co. of New York, Inc.).[4]	Buchanan, N.Y	B&W	Pressurized water	255,000	585,000	1962
Enrico Fermi Atomic Power Plant (Power Reactor Development Co.).[3 5]	Lagoona Beach, Mich	Owner	Fast breeder	60,900	200,000	1962
Hallam Nuclear Power Facility, Sheldon Station[3] (AEC and Consumers Public Power District).	Hallam, Nebr	AI	Sodium graphite	76,000	240,000	1962
Pathfinder Atomic Power Plant[3 6] (Northern States Power Co.).	Sioux Falls, S. Dak	AC	Boiling water, nuclear superheat.	62,000	203,000	1962
Big Rock Point Plant[3] (Consumers Power Co.)	Big Rock Point, Mich	GE	Boiling water	47,800	157,000	1962
Humboldt Bay Power Plant, Unit No. 3 (Pacific Gas and Electric Co.).	Humboldt Bay, Calif	GE	Boiling water	48,500	163,000	1962
PLANNED						
High Temperature Gas Cooled Reactor[3] (Philadelphia Electric Co.).	Peach Bottom, Pa	GDC	Gas cooled, graphite moderated.	40,000	117,000	1964
La Crosse Boiling Water Reactor[7] (AEC and Dairyland Power Cooperative).	Genoa, Wis	AC	Boiling water	50,000	165,000	1965
Coast Nuclear Station (Southern California Edison)	Southern Calif	West	Pressurized water	355,000	1,150,000	1965
Bodega Bay Atomic Park (Pacific Gas and Electric Co.)	Bodega Bay, Calif	Owner	Boiling water	313,000		1965

See footnotes at end of table.

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A.2. Small-Plant Prototypes

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up
Being Built						
Elk River Reactor (AEC and Rural Cooperative Power Association) [3 8]	Elk River, Minn.	AC	Boiling water	22,000	73,200	1962
Piqua Nuclear Power Facility (AEC & City of Piqua)[3]	Piqua, Ohio	AI	Organic cooled and moderated.	11,400	45,500	1962
Carolinas-Virginia Tube Reactor (Carolinas-Virginia Nuclear Power Associates, Inc.)[3 9]	Parr, S.C.	West	Pressure tube, heavy water	16,900	60,500	1962
Boiling Reactor Nuclear Superheat Project (AEC and Puerto Rico Water Resources Authority [3]	Punta Higuera, P.R.	GNEC	Boiling water, internal nuclear superheat.	16,300	50,000	1962

B. Propulsion (Maritime Seagoing Prototypes)

Name and/or owner	Nuclear designer	Shipbuilder	Type	Shaft maximum horsepower	Power, kw(t)	Start-up
Operable						
Nuclear Ship Savannah (AEC and Maritime Administration)	B & W	NYSC	Pressurized water	22,000	69,000	1961

2. Experimental Power Reactors and Reactor Experiments

A. Electric Power

A.1. Experimental Reactors

Name (All owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up	Dismantled

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2. EXPERIMENTAL POWER REACTORS AND REACTOR EXPERIMENTS

A. Electric Power

A.1. Experimental Reactors

Name (All owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up	Dis-mantled
Operable								
Experimental Boiling Water Reactor[10]	EBWR	Lemont, Ill	ANL	Boiling water	4,000	100,000	1956	
Vallecitos Boiling Water Reactor (General Electric Company and Pacific Gas and Electric Co.)	VBWR	Pleasanton, Calif	GE	Boiling water	5,000	50,000	1957	
Sodium Reactor Experiment (AEC and Southern California Edison Co.).	SRE	Santa Susana, Calif	AI	Sodium graphite	6,000	20,000	1957	
Being Built								
Experimental Breeder Reactor No. 2	EBR-2	NRTS, Idaho	ANL	Fast breeder	16,500	62,500	1962	
Boiling Reactor Experiment No. 5	BORAX-5	NRTS, Idaho	ANL	Boiling water, internal nuclear superheat.	2,650	35,700	1962	
Saxton Nuclear Experimental Reactor Project, (Saxton Nuclear Experimental Corp.).		Saxton, Pa	West	Pressurized water	3,250	20,000	1962	
Experimental Gas Cooled Reactor (AEC and Tennessee Valley Authority).	EGCR	Oak Ridge, Tenn	KE-AC	Gas cooled, graphite moderated.	22,300	84,300	1963	

See footnotes at end of table.

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A.2. Reactor Experiments

Name (All owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up	Dis-man-tled
Operated, Later Dismantled								
Boiling Reactor Experiment No. 1	BORAX-1	NRTS, Idaho	ANL	Boiling water	No elec	1,400	1953	1954
Homogeneous Reactor Experiment No. 1	HRE-1	Oak Ridge, Tenn	ORNL	Aqueous homogeneous solution (UO_2SO_4).	140	1,000	1952	1954
Los Alamos Power Reactor Experiment No. 1[11]	LAPRE-1	Los Alamos, N. Mex	LASL	Aqueous homogeneous (phosphoric acid).	No elec	2,000	1956	1957
Boiling Reactor Experiments[12]	BORAX-2,3,4	NRTS, Idaho	ANL	Boiling water	2,600	15,000	1954	1958
Los Alamos Power Reactor Experiment No. 2.	LAPRE-2	Los Alamos, N. Mex	LASL	Aqueous homogeneous (phosphoric acid).	No elec	1,000	1959	1959
Homogeneous Reactor Experiment No. 2[13].	HRE-2	Oak Ridge, Tenn	ORNL	Aqueous homogeneous solution (UO_2SO_4).	300	5,200	1957	
Operable								
Experimental Breeder Reactor No. 1[14]	EBR-1	NRTS, Idaho	ANL	Fast breader	150	1,400	1951	
Organic Moderated Reactor Experiment	OMRE	NRTS, Idaho	AI	Organic cooled and moderated.	No elec	16,000	1957	
Plutonium Recycle Test Reactor	PRTR	Hanford, Wash	GE	Heavy-water-moderated and -cooled pressure tubes.	No elec	70,000	1960	
Los Alamos Molten Plutonium Reactor Experiment.	LAMPRE-1	Los Alamos, N. Mex	LASL	Fast molten plutonium fueled, sodium cooled.	No elec	1,000	1961	
Being Built								
Heavy Water Components Test Reactor	HWCTR	Savannah River, S.C. (TC-1 Area).	duPont	Pressurized heavy water	No elec	61,000	1962	
Experimental Organic Cooled Reactor	EOCR	NRTS, Idaho	AI-PPC	Organic cooled and moderated.	No elec	40,000	1962	
Molten Salt Reactor Experiment	MSRE	Oak Ridge, Tenn	ORNL	Single region graphite moderated.		10,000	1964	
Lithium Cooled Reactor Experiment[15]			P&W	Lithium cooled			1964	
Vallecitos Experimental Superheat Reactor[16] (General Electric Company).	VESR	Pleasanton, Calif	GE	Light water moderated, separate nuclear superheater.		12,500	1962	
Fast Reactor Core Test Facility[17]	FRCTF	Los Alamos, N. Mex	LASL	Fast		20,000	1964	
Planned								
Experimental Beryllium Oxide Reactor.[18]	EBOR	NRTS, Idaho	GDC	Gas cooled, BeO moderated		10,000	1963	
Ultra-high Temperature Reactor Experiment.[19]	UHTREX	Los Alamos, N. Mex	LASL	Helium cooled	No elec	3,000	1964	

B. Space Propulsion Experiments (ROVER)

PLANNED							
Experimental Beryllium Oxide Reactor.[18]	EBOR	NRTS, Idaho	GDC	Gas cooled, BeO moderated		10,000	1963
Ultra-high Temperature Reactor Experiment.[19]	UHTREX	Los Alamos, N. Mex.	LASL	Helium cooled	No elec.	3,000	1964

B. Space Propulsion Experiments (ROVER)

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power[1] kw(t)	Start-up	Dis-man-tled
OPERATED, LATER DISMANTLED							
Nuclear Rocket Propulsion Experiment	KIWI-A	NTS, Nev.	LASL	Open cycle, hydrogen gas cooled		1959	1959
Nuclear Rocket Propulsion Experiment	KIWI-A Prime	NTS, Nev.	LASL	Open cycle, hydrogen gas cooled		1960	1960
Nuclear Rocket Propulsion Experiment	KIWI-A3	NTS, Nev.	LASL	Open cycle, hydrogen gas cooled		1960	1960
Nuclear Rocket Propulsion Experiment	KIWI-B1A	NTS, Nev.	LASL	Open cycle, hydrogen gas cooled		1961	1961
BEING BUILT							
Nuclear Rocket Propulsion Experiment	KIWI-B2A	NTS, Nev.	LASL	Open cycle, liquid hydrogen cooled.		1962	
PLANNED							
Nuclear Rocket Propulsion Experiments	KIWI-B Series	NTS, Nev.	LASL	Open cycle, liquid hydrogen		1962	

See footnotes at end of table.

C. Auxiliary Power for Space (SNAP)[20]

	Designation	Location	Principal Nuclear Contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up
Planned							
SNAP 8 Experimental Reactor	S8ER	Santa Susana, Calif.	AI	NaK cooled		600	1962
SNAP 8 Ground Prototype System	S8GPS	Santa Susana, Calif.	AI	NaK cooled	30–60	600	1963
SNAP 8 Flight Prototype System	S8FPS	Santa Susana, Calif.	AI	NaK cooled	30–60	600	1964

3. Test, Research, and Teaching Reactors

A. General Irradiation Testing

A.1. Government Facilities

Name and/or owner	Designation	Location	Principal nuclear contractor	Operator	Type	Power[1] kw(t)	Start-up
Operable							
Materials Testing Reactor (AEC)	MTR	NRTS, Idaho	Blaw-Knox	PPC	Tank	40,000	1952
Engineering Test Reactor (AEC)	ETR	NRTS, Idaho	KE	PPC	Tank	175,000	1957
Plum Brook Reactor Facility (NASA)	NASA-TR	Sandusky, Ohio	NASA		Tank	60,000	1961
Being Built							
Advanced Test Reactor (AEC)	ATR	NRTS, Idaho	Ebasco; B&W	PPC	Tank	250,000	1964

A.2. Private Facilities

Operable							
General Electric Company Materials Testing Reactor.	GETR	Pleasanton, Calif.	Owner	Owner	Tank	33,000	1958
Westinghouse Testing Reactor	WTR	Waltz Mill, Pa.	Owner	Owner	Tank	60,000	1959

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A.2. Private Facilities

OPERABLE							
General Electric Company Materials Testing Reactor.	GETR	Pleasanton, Calif.	Owner	Owner	Tank	33,000	1958
Westinghouse Testing Reactor	WTR	Waltz Mill, Pa.	Owner	Owner	Tank	60,000	1959

B. Other Testing (Special)

Name (All owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Power kw(t)[1]	Start-up
OPERABLE						
Bulk Shielding Reactor [2]	BSR-1 & BSR-2	Oak Ridge, Tenn.	ORNL	Pool	1,000	1950
Special Power Excursion Reactor Test No. 1	SPERT-1	NRTS, Idaho	PPC	Open tank	Transient	1955
Special Power Excursion Reactor Test No. 2	SPERT-2	NRTS, Idaho	PPC	Pressurized water	Transient	1958
Special Power Excursion Reactor Test No. 3	SPERT-3	NRTS, Idaho	PPC	Pressurized water	Transient	1961
Kinetic Experiment on Water Boilers	KEWB	Santa Susana, Calif.	AI	Homogeneous	50	1956
Transient Test Reactor Facility	TREAT	NRTS, Idaho	ANL	Graphite	100	1959
Fast Source Reactor	AFSR	NRTS, Idaho	ANL	Fast	1	1959
Snap Shield Test Experiment		Santa Susana, Calif.	AI	Pool	50	1961
BEING BUILT						
Special Power Excursion Reactor Test No. 4	SPERT-4	NRTS, Idaho	PPC	Pool	Transient	1962
Fast Burst Reactor	FBR	Oak Ridge, Tenn.	ORNL	Fast	1	1962

C. Research

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power [1 22] kw(t)	Start-up	Dismantled
Operated, Later Dismantled							
Los Alamos Water Boiler	HYPO	Los Alamos, N. Mex.	LASL	Homogeneous	5.5	1944	1950
Chicago Pile 1, rebuilt as CP-2 (Manhattan Engineering District-AEC).[23]	CP-1	Chicago, Ill.	Met. Lab.	Graphite	0.2 to 2	1942	1954
Argonne CP-3, rebuilt as CP-3 (Manhattan Engineering District-AEC).	CP-3	Palos Park, Ill.	Met. Lab.	Heavy water	300	1944	1954
Los Alamos Fast Reactor (AEC)	Clementine	Los Alamos, N. Mex.	LASL	Fast, plutonium fuel, mercury cooled.	25	1946	1953
Operable							
Oak Ridge Graphite Reactor (AEC)	X-10	Oak Ridge, Tenn.	CL	Graphite	3,800	1943	
Los Alamos Water Boiler (AEC)	SUPO	Los Alamos, N. Mex.	LASL	Homogeneous	25	1950	
Brookhaven Research Reactor (AEC)	BGRR	Upton, N.Y.	HKF	Graphite	20,000	1950	
Low Intensity Test Reactor (AEC) [24]	LITR	Oak Ridge, Tenn.	ORNL	Tank	3,000	1950	
North American Aviation Water Boiler Neutron Source (AEC).[25]	AE-6(WBNS)	Santa Susana, Calif.	AI	Homogeneous	2	1952	
Livermore Water Boiler (AEC)	LIWB	Livermore, Calif.	AI	Homogeneous	0.5	1953	
Argonne Research Reactor (AEC)	CP-5	Lemont, Ill.	ANL	Heavy Water	51,000	1954	
Pennsylvania State University		University Park, Pa.	Owner	Pool	200	1955	
Armour Research Foundation	ARR	Chicago, Ill.	AI	Homogeneous	75	1956	
Battelle Memorial Institute	BRR	West Jefferson, Ohio	AMF	Pool	2,000	1956	
Omega West Reactor (AEC)	OWR	Los Alamos, N. Mex.	LASL	Tank	5,000	1956	
General Electric Nuclear Test Reactor	NTR	Pleasanton, Calif.	GE	Light water	30	1957	
University of Michigan (Ford Nuclear Reactor)		Ann Arbor, Mich.	B&W	Pool	1,000	1957	
Livermore Pool Type Reactor (AEC)	LPTR	Livermore, Calif.	FW	Tank	2,000	1957	
The Curtiss-Wright Nuclear Research Laboratory of the Pennsylvania State University.[26]		Quehanna, Pa.	Owner	Pool	4,000	1958	
General Dynamics Corp.	TRIGA-Mk I	La Jolla, Calif.	GDC	U-Zr hydride, tank	250	1958	
Brookhaven Neutron Source Reactor (AEC)		Upton, N.Y.	BNL	Tank	100	1958	
Massachusetts Institute of Technology	MITR	Cambridge, Mass.	ACF	Heavy water	2,000	1958	
Industrial Reactor Laboratories, Inc. (Operated by Columbia University).		Plainsboro, N.J.	AMF	Pool	5,000	1958	
Babcock & Wilcox Lynchburg Pool Reactor	LPR	Lynchburg, Va.	Owner	Pool	450	1958	
Oak Ridge Research Reactor (AEC)	ORR	Oak Ridge, Tenn.	ORNL	Tank	30,000	1958	
Brookhaven Medical Research Reactor (AEC)	MRR	Upton, N.Y.	Daystrom	Tank	5,000	1959	
Omaha Veterans Administration Hospital	TRIGA-Mk I	Omaha, Nebr.	GDC	U-Zr hydride, tank	10	1959	
Shield Test Pool Facility	Susie	NRTS Idaho	GE	Pool	2,000	1959	
General Dynamics Corp. TRIGA Pulsing Reactor.[27]	TRIGA-Mk F	La Jolla, Calif.	Owner	U-Zr hydride, tank	1,000	1960	
University of Virginia		Charlottesville, Va.	Owner-B&W	Pool	1,000	1960	
Puerto Rico Nuclear Center (AEC)		Mayaguez, P.R.	AMF	Pool	1,000	1960	
Western New York Nuclear Research Center, Inc.		Buffalo, N.Y.	AMF	Pool	1,000	1961	
Washington State University		Pullman, Wash.	GE	Pool	100	1961	

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tory of the Pennsylvania State University.[26]						
General Dynamics Corp	TRIGA-Mk I	La Jolla, Calif	GDC	U-Zr hydride, tank	250	1958
Brookhaven Neutron Source Reactor (AEC)		Upton, N.Y	BNL	Tank	100	1958
Massachusetts Institute of Technology	MITR	Cambridge, Mass	ACF	Heavy water	2,000	1958
Industrial Reactor Laboratories, Inc. (Operated by Columbia University).		Plainsboro, N.J	AMF	Pool	5,000	1958
Babcock & Wilcox Lynchburg Pool Reactor	LPR	Lynchburg, Va	Owner	Pool	450	1958
Oak Ridge Research Reactor (AEC)	ORR	Oak Ridge, Tenn	ORNL	Tank	[illegible]	[illegible]
Brookhaven Medical Research Reactor (AEC)	MRR	Upton, N.Y	Daystrom	Tank	5,000	1959
Omaha Veterans Administration Hospital	TRIGA-Mk I	Omaha, Nebr	GDC	U-Zr hydride, tank	10	1959
Shield Test Pool Facility	Susie	NRTS Idaho	GE	Pool	2,000	1959
General Dynamics Corp. TRIGA Pulsing Reactor.[27]	TRIGA-Mk F	La Jolla, Calif	Owner	U-Zr hydride, tank	1,000	1960
University of Virginia		Charlottesville, Va	Owner-B&W	Pool	1,000	1960
Puerto Rico Nuclear Center (AEC)		Mayaguez, P.R	AMF	Pool	1,000	1960
Western New York Nuclear Research Center, Inc.		Buffalo, N.Y	AMF	Pool	1,000	1961
Washington State University		Pullman, Wash	GE	Pool	100	1961
Union Carbide Nuclear Company		Sterling Forest, N.Y	AMF	Pool	5,000	1961
University of Missouri, School of Mines and Metallurgy.		Rolla, Mo	CW	Pool	10	1961
Nuclear Science Center Reactor, Agricultural and Mechanical College of Texas.	NSCR	College Station, Tex	Convair	Pool	100	1961
BEING BUILT						
Brookhaven High Flux Beam Research Reactor (AEC).	HFBR	Upton, N.Y	BNL	Heavy water	40,000	1963
Ames Laboratory Research Reactor (AEC)	ALRR	Ames, Iowa	AMF	Heavy water	5,000	1963
Biological Research Reactor (AEC)	JANUS	Lemont, Ill	ANL	Tank	200	1962
Argonne Low Power Research Reactor (AEC)[28]	Juggernaut	Lemont, Ill	ANL	Graphite/water	250	1962
Georgia Institute of Technology	GTRR	Atlanta, Ga	GNEC	Heavy water	1,000	1962
NASA Mock-up Reactor	MUR	Sandusky, Ohio	Lockheed	Light water, pool	100	1962
Northrop Corporation (Space Radiation Laboratory).	TRIGA-Mk F	Hawthorne, Calif	GDC	U-Zr hydride, tank	100	1962
High Flux Isotope Reactor (AEC)	HFIR	Oak Ridge, Tenn	ORNL	Pool flux trap	100,000	1963
National Bureau of Standards	NBSR	Gaithersburg, Md	AC	Heavy water	10,000	1963
University of Missouri		Columbia, Mo	Owner IC	Light water	10,000	1964
PLANNED						
Rhode Island Atomic Energy Commission		Ft. Kearney, R.I	GE	Pool	3,000	1962

See footnotes at end of table.

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D. Teaching

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power [1 22] kw(t)	Startup	Dismantled
Operated, Later Dismantled							
Atomics International	L-47	Canoga Park, Calif	AI	Homogeneous	Negligible	1957	1958
American Radiator & Standard Sanitary Corp [29]	UTR-1	Mountain View, Calif	ARSS	Graphite/water	Negligible	1958	1960
General Dynamics Corp. (World Agricultural Fair-U.S. Exhibit Reactor).[30]		San Diego, Calif	GDC	TRIGA-Mk II	50	1960	1960
Operable							
North Carolina State College (Raleigh Research Reactor).[31]	RRR	Raleigh, N.C	Owner	Homogeneous	0.5	1957	
Argonne Nuclear Assembly for University Training (AEC).	Argonaut (CP-11)	Lemont, Ill	ANL	Graphite/water	10	1957	
Catholic University of America	AGN-201-101	Washington, D.C	AGN	Homog. solid	Negligible	1957	
Oklahoma State University of Agriculture and Applied Science.	AGN-201-102	Stillwater, Okla	AGN	Homog. solid	Negligible	1957	
Aerojet-General Nucleonics	AGN-201 P-103	San Ramon, Calif	AGN	Homog. solid	Negligible	1957	
University of Akron	AGN-201-104	Akron, Ohio	AGN	Homog. solid	Negligible	1957	
Agricultural and Mechanical College of Texas	AGN-201-106	College Station, Tex	AGN	Homog. solid	Negligible	1957	
University of Utah	AGN-201-107	Salt Lake City, Utah	AGN	Homog. solid	Negligible	1957	
Argonne National Laboratory (AEC)	AGN-201-108	Lemont, Ill	AGN	Homog. solid	Negligible	1957	
Colorado State University	AGN-201-109	Ft. Collins, Colo	AGN	Homog. solid	Negligible	1957	
University of California	AGN-201-112	Berkeley, Calif	AGN	Homog. solid	Negligible	1957	
University of Delaware	AGN-201-113	Newark, Del	AGN	Homog. solid	Negligible	1958	
Oregon State University	AGN-201-114	Corvallis, Oreg	AGN	Homog. solid	Negligible	1958	
Atomics International	L-77	Canoga Park, Calif	AI	Homogeneous	Negligible	1958	
Pawling Research Reactor	PRR	Pawling, N.Y	UNC	Heavy water	Negligible	1958	
William Marsh Rice University	AGN-211-101	Houston, Tex	AGN	Homog. solid, pool	Negligible	1959	
University of Oklahoma	AGN-211-102	Norman, Okla	AGN	Homog. solid, pool	Negligible	1958	
West Virginia University, College of Engineering	AGN-211-103	Morgantown, W. Va	AGN	Homog. solid, pool	Negligible	1959	
University of Arizona	TRIGA	Tucson, Ariz	GDC	U-Zr hydride, tank	10	1958	
University of Wyoming	L-77	Laramie, Wyo	AI	Homogeneous	Negligible	1959	
University of Florida	UFTR	Gainesville, Fla	GNEC	Graphite/water	10	1959	
Puerto Rico Nuclear Center (AEC)	L-77	Mayaguez, P.R	AI	Homogeneous	Negligible	1959	
Iowa State University	UTR-10	Ames, Iowa	ARSS	Graphite/water	10	1960	
Leland Stanford University		Palo Alto, Calif	GE	Pool	1	1959	
Worcester Polytechnic Institute		Worcester, Mass	GE	Pool	1	1959	
Virginia Polytechnic Institute	UTR-10	Blacksburg, Va	ARSS	Graphite/water	10	1959	
North Carolina State College		Raleigh, N.C	Cook	Graphite/water	10	1960	
University of Illinois	TRIGA-Mk II	Urbana-Champaign, Ill.	GDC	U-Zr hydride, tank	100	1960	
University of Maryland	UMNE-1	College Park, Md	AC	Tank	10	1960	
University of California at Los Angeles, College of Engineering.	Educator	Los Angeles, Calif	AMF	Graphite/water	10	1960	
University of Wisconsin		Madison, Wis	GE	Pool	10	1960	
Lockheed Aircraft Corp		USAEC South	Owner	Pool	Negligible	1960	

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West Virginia University, College of Engineering						
University of Arizona	TRIGA	Tucson, Ariz	GDC	U-Zr hydride, tank	10	1958
University of Wyoming	L-77	Laramie, Wyo	AI	Homogeneous	Negligible	1959
University of Florida	UFTR	Gainesville, Fla	GNEC	Graphite/water	10	1959
Puerto Rico Nuclear Center (AEC)	L-77	Mayaguez, P.R	AI	Homogeneous	Negligible	1959
Iowa State University	UTR-10	Ames, Iowa	ARSS	Graphite/water	10	1959
Lehigh University		Bethlehem, Penn	GE	Pool	1	1959
Worcester Polytechnic Institute		Worcester, Mass	GE	Pool	1	1959
Virginia Polytechnic Institute	UTR-10	Blacksburg, Va	ARSS	Graphite/water	10	1959
North Carolina State College		Raleigh, N.C	Cook	Graphite/water	10	1960
University of Illinois	TRIGA-Mk II	Urbana-Champaign, Ill.	GDC	U-Zr hydride, tank	100	1960
University of Maryland	UMNE-1	College Park, Md	AC	Tank	10	1960
University of California at Los Angeles, College of Engineering.	Educator	Los Angeles, Calif	AMF	Graphite/water	10	1960
University of Wisconsin		Madison, Wis	GE	Pool	10	1960
Lockheed Aircraft Corp		USAEC South American Exhibit Program.	Owner	Pool	Negligible	1960
Ohio State University		Columbus, Ohio	Lockheed	Pool	10	1960
University of Washington	Educator	Seattle, Wash	AMF	Graphite/water	10	1960
University of Kansas	Model 4180	Lawrence, Kans	BAC	Pool	10	1961
Cornell University	TRIGA-Mk II	Ithaca, N.Y	GDC	U-Zr hydride	100	1962
UTR Test Reactor (American Radiator and Standard Sanitary Corp.).		Mountain View, Calif.	Owner	Graphite/water	Negligible	1961
BEING BUILT						
Aerojet-General Nucleonics (5 reactors)	AGN-201 (126-130).	San Ramon, Calif	AGN	Homog. solid	Negligible	1962
Aerojet-General Nucleonics (5 reactors)	AGN-211	San Ramon, Calif	AGN	Homog. solid, pool	Negligible	1962
Texas Technological College		Lubbock, Tex		Pool	10	1963
Kansas State University	TRIGA-Mk II	Manhattan, Kans	GDC	U-Zr hydride, tank	10	1962
Purdue University		West Lafayette, Ind	Lockheed	Pool	0.5 to 1	1962
PLANNED						
Columbia University	TRIGA-Mk II	New York City	GDC	U-Zr hydride, tank	10	
University of Texas	TRIGA-Mk I	Austin, Tex	GDC	U-Zr hydride, tank	10	1962

See footnotes at end of table.

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PART II.—MILITARY REACTORS

1. DEFENSE POWER APPLICATIONS

A. ELECTRICAL-POWER GENERATION FOR REMOTE INSTALLATIONS

Name (All owned by DOD)	Designation [32]	Location	Prinicipal Nuclear Contractor	Type	Power Net kw(e) [1]	Start-up
OPERABLE						
Stationary Medium Power Plant No. 1 (Formerly APPR-1).	SM-1	Ft. Belvoir, Va	Alco	Pressurized water	1,855	1957
Portable Medium Power Plant No. 2A [33]	PM-2A	Camp Century, Greenland	Alco	Pressurized water	1,500	1960
BEING BUILT						
Stationary Medium Power Plant No. 1A [34]	SM-1A	Fort Greely, Alaska	Alco	Pressurized water	1,640	1962
Portable Medium Power Plant No. 3A	PM-3A	McMurdo Sound, Antarctica.	Martin	Pressurized water	1,500	1962
PLANNED						
Mobile High Power Plant No. 1A	MH1A	Liberty Ship, Walter H. Perry.	Martin	Pressurized water		1965

B. PROPULSION (NAVAL)

Name (All owned by U.S. Navy)	Designation	Nuclear Designer	Shipbuilder	Type [35]	Startup	Dismantled
OPERATED, LATER DISMANTLED						
Seawolf S2G Sodium Reactor		GE		Sodium	1956	1959
OPERABLE						
USS Nautilus	SSN571	West	Elec. Boat	S2W	1954	
USS Seawolf [36]	SSN575	West	Elec. Boat	S2Wa	1960	
USS Skate	SSN578	West	Elec. Boat	S3W	1957	
USS Swordfish	SSN579	West	Portsmouth	S4W	1958	
USS Barbel	SSN584	West	Portsmouth	S5W	1958	
USS Seadragon	SSN585	West	Elec. Boat	S4G	1959	
USS Skipjack	SSN586	GE	Elec. Boat	S3W	1959	
USS Triton (2 reactors)	SS(G)N587	West	Mare Island	S5W	1960	
USS Halibut	SSN589	West	Elec. Boat	S5W	1959	
USS Scorpion	SSB(N)598	West	Elec. Boat	S5W	1960	
USS George Washington	SSB(N)599	West	Elec. Boat	S5W	1960	
USS Patrick Henry	SSB(N)600	West	Mare Island	S5W	1960	
USS Theodore Roosevelt	SSB(N)601	West	Newport News	S5W	1961	
USS Robert E. Lee	SSN588	West	Mare Island	S5W	1961	
USS Scamp	SSN590	West	Ingalls	S5W	1961	
USS Sculpin						

REACTORS BUILT, BEING BUILT OR PLANNED

[illegible]		GE		Sodium	1956
OPERABLE					
USS Nautilus	SSN571	West	Elec. Boat	S2W	1954
USS Seawolf [a]	SSN575	West	Elec. Boat	S2Wa	1960
USS Skate	SSN578	West	Elec. Boat	S3W	1957
USS Swordfish	SSN579	West	Portsmouth	S4W	1958
USS Scorpion	SSN585	West	Elec. Boat	S5W	1959
USS Skipjack	SSN586	GE	Elec. Boat	S4G	1959
USS Triton (2 reactors)	SS(G)N587	West	Mare Island	S3W	1959
USS Halibut	SSN589	West	Elec. Boat	S5W	1960
USS Scorpion	SSB(N)598	West	Elec. Boat	S5W	1959
USS George Washington	SSB(N)599	West	Elec. Boat	S5W	1960
USS Patrick Henry	SSB(N)600	West	Elec. Boat	S5W	1960
USS Theodore Roosevelt	SSB(N)601	West	Mare Island	S5W	1960
USS Robert E. Lee	SSN588	West	Newport News	S5W	1961
USS Scamp	SSN590	West	Mare Island	S5W	1961
USS Sculpin	SSN591	West	Ingalls	S5W	1961
USS Shark	SSB(N)602	West	Newport News	S5W	1961
USS Abraham Lincoln	SSN593	GE	Portsmouth	S5W	1961
USS Thresher	SSN597	West	Portsmouth	S2C	1960
USS Tullibee	SSB(N)608	West	Elec. Boat	S5W	1961
USS Ethan Allen	CG(N)9	West	Elec. Boat	C1W	1961
USS Long Beach (2 reactors)	CVA(N)65	West	Bethlehem	A2W	1960
USS Enterprise (8 reactors)	SSN592	West	Newport News	S5W	1961
USS Snook	SSN594	West	Ingalls	S5W	1961
USS Permit	SSB(N)609	West	Mare Island	S5W	1961
USS Sam Houston	SSB(N)610	West	Newport News	S5W	1961
USS Thomas A. Edison	SSN(N)611	West	Elec. Boat	S5W	1961
USS John Marshall			Newport News	S5W	1961
BEING BUILT					
Submarine Plunger	SSN595	West	Mare Island	S5W	
Submarine Barb	SSN596	West	Ingalls	S5W	
Submarine Pollack	SSN603	West	NYSC	S5W	
Submarine Haddo	SSN604	West	NYSC	S5W	
Submarine Jack	SSN605	West	Portsmouth	S5W	
Submarine Tinosa	SSN606	West	Portsmouth	S5W	
Submarine Dace	SSN607	West	Ingalls	S5W	
Submarine Guardfish	SSN612	West	NYSC	S5W	
Submarine Flasher	SSN613	West	Elec. Boat	S5W	
Submarine Greenling	SSN614	West	Elec. Boat	S5W	
Submarine Gato	SSN615	West	Elec. Boat	S5W	
Submarine Lafayette	SSB(N)616	West	Elec. Boat	S5W	

See footnotes at end of table.

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B. Propulsion (Naval)—Continued

Name (All owned by U.S. Navy)	Designation	Nuclear Designer	Shipbuilder	Type [35]	Startup	Dismantled
Being Built—Continued						
Submarine Alexander Hamilton	SSB(N)617	West	Elec. Boat	S5W		
Submarine Thomas Jefferson	SSB(N)618	West	Newport News	S5W		
Submarine Andrew Jackson	SSB(N)619	West	Mare Island	S5W		
Submarine John Adams	SSB(N)620	West	Portsmouth	S5W		
Submarine Haddock	SSN621	West	Ingalls	S5W		
Submarine James Monroe	SSB(N)622	West	Newport News	S5W		
Submarine Nathan Hale	SSB(N)623	West	Elec. Boat	S5W		
Submarine Woodrow Wilson	SSB(N)624	West	Mare Island	S5W		
Submarine Henry Clay	SSB(N)625	West	Newport News	S5W		
Submarine Daniel Webster	SSB(N)626	West	Elec. Boat	S5W		
Guided Missile Destroyer Bainbridge (2 reactors)	DLG(N)25	GE	Bethlehem	D2G		
Guided Missile Destroyer (Frigate) (2 reactors)	DLG(N)35	GE		D2G		
Submarine	SSB(N)627	West	Newport News	S5W		
Submarine	SSB(N)628	West	Elec. Boat	S5W		
Submarine	SSB(N)629	West	Mare Island	S5W		
Submarine	SSB(N)630	West	Newport News	S5W		
Submarine	SSB(N)631	West	Elec. Boat	S5W		
Submarine	SSB(N)632	West	Newport News	S5W		
Submarine	SSB(N)633	West	Elec. Boat	S5W		
Submarine	SSB(N)634	West	Mare Island	S5W		
Submarine	SSB(N)635	West	Newport News	S5W		
Submarine	SSB(N)636	West	Portsmouth	S5W		
Submarine	SSN637					
Submarine	SSN638					
Submarine	SSN639					

A.1. Power for Remote Installations

Name (All owned by AEC except as noted)	Designation [33]	Location	Principal nuclear contractor	Type	Power [1]		Start up	Dismantled
					Net kw(e)	Kw(t)		
Operated, Later Dismantled								
Stationary Low Power Plant No. 1 (Formerly ALPR).[37]	SL-1	NRTS, Idaho	ANL	Boiling water	200		1958	1961

Operable

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Submarine	SSN639							

A.1. Power for Remote Installations

Name (All owned by AEC except as noted)	Designation [33]	Location	Principal nuclear contractor	Type	Power [1] Net kw(e)	Power [1] Kw(t)	Start up	Dismantled
OPERATED, LATER DISMANTLED								
Stationary Low Power Plant No. 1 (Formerly ALPR).[37]	SL-1	NRTS, Idaho	ANL	Boiling water	200		1958	1961
OPERABLE								
Gas Cooled Reactor Experiment	GCRE-1	NRTS, Idaho	AGN	Gas cooled, light water moderated.	No elec	2,200	1960	
Mobile Low Power Plant No. 1	ML-1	NRTS, Idaho	AG	Gas cooled	300 to 500	3,300	1962	
BEING BUILT								
Portable Medium Power Plant No. 1 (USAF-AEC).[38]	PM-1	Sundance, Wyo	Martin	Pressurized water	1,000		1961	
PLANNED								
Portable Low Power Plant No. 3 [39]	PL-3	Byrd Station, Antarctica			1,000		1964	

A.2. Special Purpose (Auxiliary Power for Space)

Name	Designation	Location	Principal nuclear contractor	Type	Power [1] Net kw(e)	Power [1] Kw(t)	Start up [1]	Dismantled
OPERATED, LATER DISMANTLED								
SNAP 2 Experimental Reactor	SER	Santa Susana, Calif	AI	NaK cooled		50	1959	1961
OPERABLE								
SNAP 2 Developmental System No. 1	S2DS	Santa Susana, Calif	AI	NaK cooled	3	50	1961	
PLANNED								
SNAP 2 Flight System No. 1	S2FS-I	Santa Susana, Calif	AI	NaK cooled	3	50	1963	
SNAP 10 Flight System No. 1	S10FS-I	Santa Susana, Calif	AI	NaK cooled	0.5	30	1962	

See footnotes at end of table.

B. Propulsion Experiments and Prototypes

B.1. Naval

Name (All owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power [1] kw(t)	Start-up	Dis-mantled
Operated, Later Dismantled							
Submarine Intermediate Reactor Mark A	S1G	West Milton, N.Y.	GE	Sodium		1955	1957
Operable							
S1W Reactor Facility	S1W	NRTS, Idaho	West	Pressurized water		1953	
Large Ship Reactor Prototype (2 reactors)	A1W	NRTS, Idaho	West	Pressurized water		1958	
Submarine Advanced Reactor Prototype	S3G	West Milton, N.Y.	GE	Pressurized water		1958	
Small Submarine Reactor Prototype	S1C	Windsor, Conn.	GE	Pressurized water		1959	
Being Built							
Destroyer Reactor Prototype	D1G	West Milton, N.Y.	GE	Pressurized water		1962	
Natural Circulation Test Plant	S5G	NRTS, Idaho	GE	Pressurized water		1963	

B.2. Aircraft

Operated, Later Dismantled							
Aircraft Reactor Experiment	ARE	Oak Ridge, Tenn.	ORNL	Molten salt		1954	1954
Heat Transfer Reactor Experiment No. 1 [40]	HTRE-1	NRTS, Idaho	ANPD	Air cooled	20,000	1956	1957
Operable							
Heat Transfer Reactor Experiment No. 2 [41]	HTRE-2	NRTS, Idaho	ANPD	Air cooled	14,000	1957	
Heat Transfer Reactor Experiment No. 3 [41]	HTRE-3	NRTS, Idaho	ANPD	Air cooled	32,000	1958	

B.3. Missile (Project PLUTO)

Operated, Later Dismantled							
Experimental Propulsion Test Reactor	Tory-IIA-1	NTS, Nev.	UCLRL	Air cooled	160,000	1959	
Being Built							
Experimental Propulsion Test Reactor	Tory-IIC	NTS, Nev.	UCLRL	Air cooled	[illegible]	[illegible]	

Name (All owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power kw(t)	Start-up	Dis-mantled
Operated, Later Dismantled							
Tower Shielding Reactor No. 1	TSR-1	Oak Ridge, Tenn.	ORNL	Tank	500	1954	1958
Operable							
Ground Test Reactor (USAF) [41]	GTR	Ft. Worth, Tex.	Convair	Pool	3,000	1953	
Aircraft Shield Test Reactor (USAF) [41]	ASTR	Ft. Worth, Tex.	Convair	Light water	3,000	1954	
Radiation Effects Reactor (USAF)	RER	Dawsonville, Ga.	Lockheed	Tank	10,000	1958	
Tower Shielding Reactor No. 2	TSR-2	Oak Ridge, Tenn.	ORNL	Light water	5,000	1960	

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Name (All owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power kw(t)	Start-up	Dismantled
OPERATED, LATER DISMANTLED							
Tower Shielding Reactor No. 1	TSR-1	Oak Ridge, Tenn	ORNL	Tank	500	1954	1958
OPERABLE							
Ground Test Reactor (USAF) [41]	GTR	Ft. Worth, Tex	Convair	Pool	3,000	1953	
Aircraft Shield Test Reactor (USAF) [41]	ASTR	Ft. Worth, Tex	Convair	Light water	3,000	1954	
Radiation Effects Reactor (USAF)	RER	Dawsonville, Ga	Lockheed	Tank	10,000	1958	
Tower Shielding Reactor No. 2	TSR-2	Oak Ridge, Tenn	ORNL	Light water	5,000	1960	
Sandia Pulsed Reactor Facility	SPRF	Sandia Base, N. Mex	Sandia	Prompt burst		1961	
Shield Test Experiment	STE	Santa Susana, Calif	AI	Pool	50	1961	
BEING BUILT							
Nuclear Engineering Test Reactor (USAF) [42]	NETR	Dayton, Ohio	Maxon-AC	Pool	10,000	1961	
Sandia Engineering Reactor Facility	SERF	Sandia Base, N. Mex	Sandia	Tank	5,000	1962	

B. RESEARCH

OPERABLE							
Thermal Test Reactor No. 1	TTR-1	Schenectady, N.Y	KAPL	Graphite	10	1951	
Naval Research Reactor (USN)	NRR	Washington, D.C	NRL	Pool	1,000	1956	
National Naval Medical Center (USN)	AGN-201M-105	Bethesda, Md	AGN	Homog. solid	Negligible	1957	
U.S. Naval Post Graduate School (USN)	AGN-201-100	Monterey, Calif	AGN	Homog. solid	Negligible	1956	
Horace Hardy Lester Reactor for Materials Research (Watertown Arsenal, USA).		Watertown, Mass	Owner	Pool	1,000	1961	
Diamond Ordnance Fuse Laboratory Radiation Facility (USA).[27]	TRIGA-Mk-F (DORF).	Washington, D.C	GDC	Heterog., tank	100	1961	
BEING BUILT							
Walter Reed Army Institute of Research (USA).	L-54	Washington, D.C	AI	Homogeneous	50	1962	
Biomedical Radiation Research Facility (DOD).	DASA-TRIGA	Bethesda, Md	GDC	U-Zr hydride, tank	100	1962	
PLANNED							
White Sands Missile Range Nuclear Effects Facility (USA).	WSMR	White Sands, N. Mex	Hughes	Prompt burst		1963	

See footnotes at end of table.

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PART III.—PRODUCTION REACTORS

1. MATERIALS PRODUCTION

Designation	Nuclear designer	Type	Location
OPERABLE			
B Reactor	du Pont	Graphite	Hanford, Wash.
D Reactor	du Pont	Graphite	Hanford, Wash.
F Reactor	du Pont	Graphite	Hanford, Wash.
C Reactor	GE	Graphite	Hanford, Wash.
DR Reactor	GE	Graphite	Hanford, Wash.
H Reactor	GE	Graphite	Hanford, Wash.
KE Reactor	GE	Graphite	Hanford, Wash.
KW Reactor	GE	Graphite	Hanford, Wash.
R Reactor	du Pont	Graphite	Hanford, Wash.
P Reactor	du Pont	Heavy water	Savannah River, S.C.
K Reactor	du Pont	Heavy water	Savannah River, S.C.
L Reactor	du Pont	Heavy water	Savannah River, S.C.
C Reactor	du Pont	Heavy water	Savannah River, S.C.
BEING BUILT			
New Production Reactor [43]	GE	Graphite	Hanford, Wash.

2. PROCESS DEVELOPMENT

Name (All owned by AEC)	Designation	Location	Nuclear Designer	Type	Power kw(t)	Start-up
OPERABLE						
Process Development Pile	PDP	Savannah River, S.C.	du Pont	Heavy water	1	1953
Hanford 305 Test Reactor	HEW-305	Hanford, Wash.	du Pont	Graphite	0.03	1944
Savannah River Test Pile 305	SR-305	Savannah River, S.C.	du Pont	Graphite	1	1953
Physical Constants Test Reactor	PCTR	Hanford, Wash.	GE	Graphite	0.1	1955
Thermal Test Reactor No. 2	TTR-2	Hanford, Wash.	GE	Graphite	0.1	1955
Thermal Test Reactor	SP	Savannah River, S.C.	du Pont	Graphite	2 to 10	1958

PART IV.—REACTORS FOR EXPORT

1. POWER REACTORS

A. CENTRAL-STATION ELECTRIC POWER

Name and/or owner	Location	Principal nuclear contractor	Type	Power [1]		Startup
				Net kw(e)	Kw(t)	
OPERABLE						

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Thermal Test Reactor	PCTR	Hanford, Wash	GE	Graphite	0.1	1955
Thermal Test Reactor No. 2	TTR-2	Hanford, Wash	GE	Graphite	0.1	1955
Thermal Test Reactor	SP	Savannah River, S.C	du Pont	Graphite	2 to 10	1953

PART IV.—REACTORS FOR EXPORT

1. POWER REACTORS

A. CENTRAL-STATION ELECTRIC POWER

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1]		Startup
				Net kw(e)	Kw(t)	
OPERABLE						
Germany (Rhine-Westphalia Power Co., RWE)	Kahl-am-Main	GE	Boiling water	15,000	60,000	1960
BEING BUILT						
Belgium (Center for the Study of Nuclear Energy, CEN)	Mol	West	Pressurized water	11,500	43,000	1962
Italy (Project Enrico Fermi of SELNI, Edisonvolta)	Trina	West	Pressurized water	165,000	615,000	1964
Italy (Project ENSI of SENN)	Punta Fiume	GE	Boiling water	150,000	508,000	1963
Japan, Government of (JAERI)	Tokai-Mura	GE	Boiling water	12,000	45,000	1963
PLANNED						
France (Franco-Belgium Society for Nuclear Energy of Ardennes—SENA).	Chooz	West	Pressurized water	242,000	825,000	1965

B. PROPULSION

Name	Owner	Designer	Type	Start-up
BEING BUILT				
S5W for HMS Dreadnaught	Great Britain	West	S5W	

See footnotes at end of table.

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2. Test, Research, and Teaching

A. General Irradiation Test

Owner	Location	Principal nuclear contractor	Type	Power kw(t) [1 22]	Start-up
Operable					
Sweden, Government of (Atomic Energy Company)	Studsvik	AC	Tank (MTR)	30,000	1960
Japan, Government of (Atomic Energy Research Institute)	Tokai-Mura	AMF	Heavy water, tank	10,000	1960
Netherlands, Government of (Reactor Center)	Petten	AC	Tank (MTR)	20,000	1961
Planned					
South Africa, Government of (Atomic Energy Board)	Pelindaba, S. Africa	AC	Tank	20,000	1963

B. Research

Owner	Location	Principal nuclear contractor	Type	Power kw(t) [1 22]	Start-up
Operable					
Austria, Government of (Seibersdorf Research Center)	Seibersdorf	AMF	Pool	5,000	1960
Brazil, Government of (University of Sao Paulo)	Sao Paulo	B&W	Pool	5,000	1957
Canada (McMaster University)	Hamilton, Ont.	AMF	Pool	1,000	1959
China, Republic of (National Tsing-Hua University)	Hsinchu	GE	Pool	1,000	1961
Denmark, Government of (Atomic Energy Commission)	Riso	FW	Tank	5,000	1958
Germany, Federal Republic of (Technical University of Munich)	Munich	AMF	Pool	1,000	1957
Germany, Federal Republic of (Society for the Utilization of Nuclear Energy in Shipbuilding and Navigation, Inc.).	Geesthacht	B&W	Pool	5,000	1958
Greece, Government of (Atomic Energy Commission)	Athens	AMF	Pool	1,000	1961
Israel, Government of (Atomic Energy Commission)	Nebi Rubin	AMF	Pool	5,000	1960
Italy, Government of (National Committee for Nuclear Research)	Ispra	AC	Heavy water, tank	5,000	1959
Italy, Government of (National Committee for Nuclear Research)	Rome	GDC	TRIGA-Mk II	100	1960
Italy (SORIN Nuclear Center)	Saluggia	AMF	Pool	1,000	1959
Portugal, Government of (Nuclear Energy Board)	Sacavem	AMF	Pool	1,000	1961
Spain, Government of (Nuclear Energy Board)	Moncloa	GE	Pool	3,000	1958
Switzerland, Government of (Reactor, Inc.) [44]	Wuerenlingen	ORNL	Pool	1,000	1955
Turkey, Government of (Atomic Energy Commission)	Istanbul	AMF	Pool	1,000	1961
Venezuela, Government of (Institute of Neurology and Brain Research) [45]	Caracas	GE	Pool	3,000	1960
Iran, Government of (University of Tehran)	Tehran	B&W	Pool	5,000	1962
Italy (Naval Academy, University of Pisa, and C.A.M.E.N.)	Livorno	GDC	TRIGA-Mk II	100	1962
Korea, Government of (Atomic Energy Commission)	Seoul	AMF	Pool	100	1962
Netherlands, Government of (Delft Technical University) [46]	Delft	AMF	Pool	5,000	1963
Pakistan, Government of (Atomic Energy Commission)	Rawalpindi	GE	Pool	1,000	1962
Phillipines, Government of (National Science Development Board)	Quezon City	CW	Pool	1,000	1962
Thailand (Chulalongkorn University)	Bangkok	GDC	TRIGA-Mk II	100	1962
Vietnam, Government of	Dalat	GDC	TRIGA-Mk II	100	1962
Planned					
Yugoslavia, Federal People's Government of (Josef Stefan Nuclear Institute).	Ljubljana				

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Italy, Government of (National Committee for Nuclear Research)	Nebi Rubin	AMF	Pool	1,000	1961
Italy, Government of (National Committee for Nuclear Research)	Ispra	AC	Heavy water, tank	5,000	1960
Italy (SORIN Nuclear Center)	Rome	GDC	TRIGA-Mk II	5,000	1959
Portugal, Government of (Nuclear Energy Board)	Saluggia	AMF	Pool	100	1960
Spain, Government of (Nuclear Energy Board)	Sacavem	AMF	Pool	1,000	1959
Switzerland, Government of (Reactor, Inc.) [46]	Moncloa	GE	Pool	1,000	1961
Turkey, Government of (Atomic Energy Commission)	Wuerenlingen	ORNL	Pool	3,000	1958
Venezuela, Government of (Institute of Neurology and Brain Research) [46]	Istanbul	AMF	Pool	1,000	1955
	Caracas	GE	Pool	1,000	1961
Iran, Government of (University of Tehran)	Tehran	[illegible]	[illegible]	3,000	1960
Italy (Naval Academy, University of Pisa, and C.A.M.E.N.)	Livorno	B&W	Pool	[illegible]	[illegible]
Korea, Government of (Atomic Energy Commission)	Seoul	GDC	TRIGA-Mk II	100	1962
Netherlands, Government of (Delft Technical University) [46]	Delft	AMF	Pool	100	1962
Pakistan, Government of (Atomic Energy Commission)	Rawalpindi	AMF	Pool	5,000	1963
Phillipines, Government of (National Science Development Board)	Quezon City	GE	Pool	1,000	1962
Thailand (Chulalongkorn University)	Bangkok	CW	Pool	1,000	1962
Vietnam, Government of	Dalat	GDC	TRIGA-Mk II	100	1962
PLANNED					
Yugoslavia, Federal People's Government of (Josef Stefan Nuclear Institute).	Ljubljana	GDC	TRIGA-Mk II	100	1962

C. TEACHING

OPERABLE					
Australia (Atomic Energy Commission)	Lucas-Heights, New South Wales.	ARSS	UTR-10	10	1961
Brazil (University of Minas Gerais)	Belo Horizonte	GDC	TRIGA-Mk I	30	1960
Congo, Government of (University of Lovanium) [47]	Leopoldville	GDC	TRIGA-Mk I	50	1959
Denmark, Government of (Atomic Energy Commission)	Riso	AI	L-55	0.5	1957
Germany, Federal Republic of (Universities of Frankfurt and Darmstadt)	Frankfurt	AI	L-54	50	1958
Germany (Interatom, Inc.) [48]	Duisburg	AI	L-77	Negligible	1958
Italy (University of Palermo)	Palermo	AGN	211-110	Negligible	1960
Italy (University of Milan)	Milan	AI	L-54	50	1959
Japan, Government of (Atomic Energy Research Institute)	Tokai-Mura	AI	L-54	50	1957
Japan (Kinki University)	Osaka	ARSS	UTR-10	Negligible	1961
Japan (Rikkyo University)	Yokosuka City	GDC	TRIGA-Mk II	100	1961
Switzerland (University of Geneva) [49]	Geneva	AGN	201-111	Negligible	1958
Switzerland (University of Basel) [50]	Basel	AGN	211-100	Negligible	1958
West Berlin, City of (Institute for Nuclear Research)	West Berlin	AI	L-54	50	1958
BEING BUILT					
Austria, Government of (Vienna Polytechnic Institute)	Vienna	GDC	TRIGA-Mk II	100	1962
Finland, Government of (Institute of Technology)	Helsinki	GDC	TRIGA-Mk II	100	1962
Japan (Musashi University)	Kawasaki City	GDC	TRIGA-Mk II	100	1962
PLANNED					
Germany (Johannes Gutenberg, University of Mainz)	Mainz	GDC	TRIGA-Mk II	30	1962
Japan (Tokai University)	Nagoya	ARSS	UTR-10	Negligible	

See footnotes at end of table.

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PART V.—CRITICAL ASSEMBLY FACILITIES

A. IDENTIFICATION OF FACILITIES

Abbreviation	Name and location of facility	Operator	No. of cells	No. of control panels
AC	Allis-Chalmers Critical Experiment Facility, Greendale, Wis	Owner	1	1
AI	Atomics International Critical Experiment Laboratory (AEC), Santa Susana, Calif	Owner	4	4
Alco	Alco Products, Inc., Schenectady, N.Y	Owner	1	1
ANL	Argonne National Laboratory (AEC), Lemont, Ill	ANL	5	5
ANL-ID	Argonne National Laboratory, Idaho Division (AEC), NRTS, Idaho	ANL	1	1
ARMF	Advanced Reactivity Measurement Facility (AEC), NRTS, Idaho	PPC	1	1
ATRC	Advanced Test Reactor Critical Facility (AEC), NRTS, Idaho	PPC	1	1
Bettis	Bettis Plant (AEC), Pittsburgh, Pa	West	6	6
BMI	Battelle Memorial Institute, West Jefferson, Ohio	Owner	1	1
BNL	Brookhaven National Laboratory (AEC), Upton, N.Y	BNL	2	2
B&W	The Babcock & Wilcox Co., Lynchburg, Va	Owner	3	3
CANEL	Connecticut Aircraft Nuclear Engine Laboratory (AEC), Middletown, Conn	P&W	2	2
CE	Nuclear Engine Laboratory of Combustion Engineering, Inc., Windsor, Conn	Owner	3	2
Cornell	Cornell University Zero Power Reactor, Ithaca, N.Y	Owner	1	1
ETRC	Engineering Test Reactor Critical Facility (AEC), NRTS, Idaho	PPC	1	1
GDC	General Dynamics Corp., San Diego, Calif	Owner	3	3
GE	General Electric Company, Vallecitos Laboratory Experimental Physics Facility, Pleasanton, Calif	Owner	1	1
GEANP	Evendale Critical Experiment Facility (AEC), Evendale, Ohio	GE	2	2
HAN-CML	Hanford Critical Mass Laboratory (AEC), Hanford, Wash	GE	1	1
HAN-PRCF	Plutonium Recycle Critical Facility (AEC), Hanford, Wash	GE	1	1
KAPL	Knolls Atomic Power Laboratory (AEC), Schenectady, N.Y	GE	7	7
LAC	Lockheed Aircraft Corp., Dawsonville, Ga. (USAF)	Owner	1	1
LASL	Los Alamos Scientific Laboratory, Los Alamos, N. Mex	LASL	3	2
Livermore	University of California Lawrence Radiation Laboratory Critical Assembly Area (AEC), SAGA Building, Livermore, Calif.	UCLRL	4	3
LPTF	Low Power Test Facility (AEC), NRTS, Idaho	GE	2	2
Martin	Martin Co., Middle River, Md	Owner	3	3
NAA	North American Aviation, Inc., SNAP Critical Experimental Facility (AEC) Santa Susana, Calif	AI	1	1
NASA	Lewis Flight Propulsion Laboratory, Sandusky, Ohio	Owner	1	1
ORNL-CF	Oak Ridge National Laboratory Critical Facility (AEC), Oak Ridge, Tenn	ORNL	1	1
ORNL-PCA	Pool Critical Assembly, BSF Pool (AEC), Oak Ridge, Tenn	ORNL	1	1
RMF	Reactivity Measurement Facility, NRTS Critical (AEC), NRTS, Idaho	[illegible]	[illegible]	[illegible]
UCLRL-NTS	University of California Lawrence Radiation Laboratory (AEC), NTS, Nev	UCLRL	1	1
UNC	United Nuclear Corp., Development Division	Owner	3	3
West	Westinghouse Reactor Evaluation Center Critical Experiment Station (CES), Yankee Critical Facility (YCF), and Large Reactor Critical Facility (LRX), Waltz Mill, Pa.	Owner		

B. IDENTIFICATION OF EXPERIMENTS AND STUDIES

B.1. Civilian

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Martin	Martin Co., Middle River, Md			
NAA	North American Aviation, Inc., SNAP Critical Experimental Facility (AEC) Santa Susana, Calif	Owner	3	3
NASA	Lewis Flight Propulsion Laboratory, Sandusky, Ohio	AI	1	1
ORNL-CF	Oak Ridge National Laboratory Critical Facility (AEC), Oak Ridge, Tenn	Owner	1	1
ORNL-PCA	Pool Critical Assembly, BSF Pool (AEC), Oak Ridge, Tenn	ORNL	3	3
UCLRL-NTS	University of California Lawrence Radiation Laboratory (AEC), NTS, Nev	UCLRL	1	1
UNC	United Nuclear Corp., Development Division	Owner	1	1
West	Westinghouse Reactor Evaluation Center Critical Experiment Station (CES), Yankee Critical Facility (YCF), and Large Reactor Critical Facility (LRX), Waltz Mill, Pa.	Owner	3	3

B. Identification of Experiments and Studies

B.1. Civilian

Facility	Subject of current experiment or study	Designation	Startup
Operable			
AC	Northern States Power Reactor critical experiment	CRBR-CX	1959
AI, ECEL	Nuclear properties of epithermal reactor systems	AETR	1960
AI, OMCA	Nuclear properties of organic-moderated systems	OMCA	1959
AI, SCGA	Nuclear properties of sodium-graphite systems	SCGA	1959
ANL, Building 316, Cell A[51]	Argonne Thermal Source Reactor (Formerly called ZPR-4)	ATSR	1957
ANL, Building 316, Cell B	Contains ZPR-7 facility; high conversion (Hi-C) critical experiments	ZPR-7	1956
ANL, Building 316, Cell C	Flux-trap configuration critical studies (Formerly ZPR-5)		1957
ANL-ID	Fast critical mass determinations	ZPR-3	1955
Bettis	PWR core 2 physics	PWR-FA	1954
BMI, Cell 1	Experiments with plastic-moderated assembly	BMI-CX	1957
BNL, Building T-526	Exponential and critical assembly		1956
B&W, Cell 1	Consolidated Edison reactor		1957
B&W, Cell 2[52]	Spectral Shift Control Reactor		1958
B&W, Cell 3[52]	Lynchburg Source Reactor (LSR)		1958
CE, Building 1, Cell 1	Vacant		
CE, Building 2, Cell 1	Boiling nuclear superheat critical experiment	BONUS	1961
CE, Building 2, Cell 2	Integral nuclear superheat core configuration	NUSU	1960
ARMF, ETR-MTR Area (PPC)	Reactor physics constants and reactivity changes caused by test reactor irradiation	ARMF	1960
ETRC, ETR-MTR Area (PPC)	ETR physics, core loading and core design	ETRC	1957
GDC, Cell 1	Zirconium-uranium hydride fuel	CIRGA	1957
GDC	HTGR critical experiment	HTGR-CX	1960

See footnotes at end of table.

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B. Identification of Experiments and Studies—Continued

B.1. Civilian—Continued

Facility	Subject of current experiment or study	Designation	Startup
Operable—Continued			
GDC	Maritime Gas Cooled Reactor critical experiment	MGCR-CX	1960
GE, Cell 1	Nuclear superheat core configuration		1961
HAN-CML	Critical Mass Laboratory	CML	1961
HAN-PRCF	Plutonium Recycle Criticals	PRCF	1961
LASL, Kiva I	Cold criticals for ROVER reactors	Honeycomb	1957
LASL, Kiva II	Physics measurements of thin enriched-uranium foils in thick D_2O cold critical experiments	Cavity	1960
LASL, Kiva III	Kiva heated critical assembly		1961
LASL	Cold criticals for ROVER reactors	ZEPO's	1958
Martin, Cell 1	Martin power reactor experiments		1957
Martin, Cell 2	Homogeneous dispersions in a plastic of uranium, stainless steel, and boron		1958
Martin, Cell 3	Liquid Fluidized Bed Reactor critical experiment facility	LFBR-CX	1961
NASA, Materials and Stresses Building	NASA Test Reactor critical experiments		1959
ORNL-CF, Building 9213, Cell E	Uranium-paraffin experiments related to physics and safety of homogeneous reactors	CA-28	1950
ORNL-CF, Building 9213, Cell S	Comparison of nuclear properties of U-235 and U-233		
ORNL-CF, Building 9213, Cell W	Reactor-physics and nuclear safety studies with homogeneous uranium solutions; slightly enriched uranium lattices in water; TSR-2 tests; investigations of neutron absorbers as poisons in chemical-processing equipment.		1950
ORNL-PCA, Building 3010	Physics research on reactivity effects	PCA	1958
RMF, MTR canal	Reactor physics constants and reactivity changes caused by test reactor irradiation	RMF	1954
West., CES	Reactor-fuel-measurement facility design		1958
West., LRX	Physical constants of critical assemblies moderated with D_2O and containing as fuel slightly enriched uranium in the form of UO_2.	CVTR-LRX	1961
West., YCF	Loose lattice critical experiments.		
Being Built			
ANL, Building 315, Cell 5	Basic fast reactor theoretical studies	ZPR-6	1962
ANL, Building 315, Cell 4	Coupled fast core—thermal breeder blanket investigations	ZPR-9	1963
Cornell	Reactor Physics Research	ZEPR	1962
Planned			
ATRC, ATR Area (PPC)	ATR physics, core loading and core design measurements	ATRC	1964
Operable			
Alco	APPR-1A core design	APPR-s	1956
Bettis	D1W physics	DPE	1961
Bettis	Clean Critical Experiments	RDA-CF	1961
Bettis	Surface-ship physics [53]	SS-CF	1957
Bettis	Physics measurements	SPE	1960
Bettis	High-temperature physics and mock-up	HTTF	1959
Bettis	Vacant		
CANEL, Physics Building, Cell 1	Vacant		
CANEL, Physics Building, Cell 2	Vacant		
GEANP-1	Vacant		
GEANP-2	Vacant	PPA	1948
KAPL	Physical data		

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Planned			
ATRC, ATR Area (PPC)	Reactor Physics Research	ZEPR	1962
	ATR physics, core loading and core design measurements	ATRC	1964
Operable			
Alco	APPR-1A core design	APPR-s	1956
Bettis	D1W physics	DPE	1961
Bettis	Clean Critical Experiments	RDA-CF	1961
Bettis	Surface-ship physics [53]	SS-CF	1957
Bettis	Physics measurements	SPE	1960
Bettis	High-temperature physics and mock-up	HTTF	1959
CANEL, Physics Building, Cell 1	Vacant		
CANEL, Physics Building, Cell 2	Vacant		
GEANP-1	Vacant		
GEANP-2	Vacant		
KAPL	Physical data	PPA	1948
KAPL	Reactor physics studies with plastic moderator and mock-up	PMA	1954
KAPL	Submarine advanced reactor mock-up	ATR	1954
KAPL	SAR physics and mock-up	FPR	1956
KAPL	D1G cold-water mock-up	CWA	1958
KAPL	SAR high-temperature and -pressure physics and mock-up	PTR	1958
KAPL	Cold Water Test Assembly	CWTA	1960
LAC	RER core configurations	CERF	1958
LASL	Enriched metal in 3-in.-thick uranium reflector	Little Eva	1951
LASL, Kiva I	Plated bare-plutonium (to be replaced by U-233) sphere studies	Jezebel	1954
LASL, outside Kiva II	Jacketed enriched-core lateral and base reflector of water studies, used as neutron sources for exponential column.	Hydro	1956
LASL, Kiva II	Super prompt critical bursts with plated bare enriched core	Godiva II	1957
LASL, Kiva II	Spherical metal cores in thick metal reflector	Flattop	1957
LASL, Kiva I	Critical configuration safety tests	Comet II	1953
LASL, Kiva II	Critical configuration safety tests	Planet	1952
LASL	Critical configuration safety tests		
Livermore, SAGA Building	Critical measurements with different geometrics		1953
Livermore, SAGA Building	Project PLUTO cold critical experiments		1957
Livermore, SAGA Building	Fast critical experiments	Kukla	1959
LPTF, Cell 1	Hot critical experiments	HOTCE	1958
LPTF, Cell 2	Critical experiment tank for HTRE-2	CET	1957
NAA-AI	Criticals for SNAP reactors		
UCLRC, NTS, Nevada	Hot criticals for Tory-II (Project PLUTO)	Hot Box	
Being Built			
Livermore, SAGA Building	Tory-II critical experiments		1960

See footnotes at end of table.

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FOOTNOTES

[1] The capacity figures for power reactors are based on the best available information. In some cases future modification in plans may cause changes. For reactors under construction or planned, plant capacity is rounded to the nearest hundred kilowatt.

[2] The Shippingport station is provided with a turbogenerator rated at 100,000 kw(e). Construction of a heat sink to permit operation at 150,000 kw(e) gross equivalent is in progress.

[3] This project is under the Power Demonstration Reactor Program.

[4] Of the total net electrical output shown for the Consolidated Edison plant, 151,000 kw will be nuclear and 104,000 kw will be oil-fired superheat.

[5] The Enrico Fermi plant is to be provided with a turbogenerator rated at 150,000 kw(e) and may reach this gross output with later cores.

[6] The capacity of the Northern States plant includes about 17,000 kw(e) nuclear superheat.

[7] This reactor is approved as basis for the AEC contract negotiations under the Power Demonstration Reactor Program.

[8] The thermal output of the Elk River plant includes about 15,000 kw conventional superheat.

[9] Capacity of CVNPA plant includes about 2000 kw(e) from conventional superheat.

[10] EBWR was successfully operated at a power level of 62,000 kw of heat in experiments on March 20, 1958. It has been converted to a 100,000-kw thermal plant, but its electrical output is limited by turbogenerator capacity.

[11] LAPRE-1 was designed as a small reactor experiment that was to produce 2000 kw of heat power. It operated very briefly and never succeeded in reaching full power.

[12] This facility was originally built and operated in 1954 as the Boiling Reactor Experiment No. 2 (BORAX-2). With the addition of a turbogenerator, it operated during 1955 as BORAX-3. BORAX-4 was a further modification, which operated from December 1956 until June 1958, when the experiment was shut down.

[13] HRE-2 has been shut down, placed on a stand-by basis, and may be dismantled in the near future.

[14] Gross electrical kilowatt output is shown for EBR-1 in the tabulation. In a trial run on December 21 and 22, 1951, EBR-1 generated the world's first electric power from nuclear energy. Criticality with the third core was achieved in November 1957. A plutonium bearing core (Mark IV) has been fabricated and will be loaded in the reactor in 1962.

[15] This reactor experiment utilizes technology developed under the Aircraft Nuclear Propulsion Program, which was cancelled early in 1961.

[16] Saturated steam will be supplied by VBWR or a separate gas-fired boiler. At a later date GE plans to make interconnections and operate the VESR at thermal power levels up to 23 Mw to superheat saturated steam from either or both the VBWR or the gas-fired boiler and to discharge a portion of the superheated steam generated in the VESR to the VBWR turbine-condenser system.

[17] Lampre-2, a 15-Mw(t) device, is scheduled to be the first of a series of experiments to be conducted in this facility.

[18] EBOR is to be constructed in the Shield Test Pool Facility, which was formerly used for shielding studies in the Aircraft Nuclear Propulsion Program.

[19] The purpose of UHTREX, formerly known as Turret, is to investigate problems associated with ultra-high-temperature gas-cooled reactors using unclad fuel elements.

[20] These reactors are being developed for both civilian and military applications.

[21] BSR-2 is a stainless steel UO_2 core that became operable in 1959 which can be used alternately in the same facility with BSR-1 (aluminum alloy core).

[22] Reactors whose thermal power output is less than 50 watts are shown as having negligible power output. The thermal power of these reactors is as follows: AGN 201's, 100 mw; AGN 201M's, 5 watts; AGN 201P's, 20 watts; AGN 211's, 15 watts; AI's L-47, and L-77, 10 watts; ARSS' UTR-1, 1 watt; and NDA's PRR, 5 watts.

[23] In 1943, the Manhattan Engineering District disassembled Chicago Pile 1 and rebuilt it at Palos Park, Ill., as Chicago Pile 2. CP-2 had a thermal power level of 10 kw.

[24] LITR began as a mechanical model of the MTR. After MTR engineering aspects were proved, small amounts of nuclear fuel, control devices, shielding, and instruments were added; and the reactor, called MTR critical experiment, went critical for the first time in the spring of 1950. Research facilities were added, and power was increased to the present level in the fall of 1951.

[25] AE-6, also designated WBNS, was built and first operated at Downey, Calif. It was moved to Santa Susana in 1957.

[26] Ownership of the Curtiss-Wright Research Reactor Facility was transferred to Pennsylvania State University in December 1960. The reactor is being maintained on a stand-by basis pending issuance of an operating license to the university.

[27] This reactor is capable of being pulsed to peak power levels of approximately 1,200,000 kw for fractions of a second at repeated intervals.

[28] After the assembly and operation of this reactor in the Government exhibit at Geneva in September 1958, it was dismantled and returned to ANL, where it is being rebuilt as a 250-kw(t) Juggernaut.

[29] This reactor was shipped abroad for exhibition purposes in Pakistan and Egypt in 1960.

[30] [illegible]

[31] The original 10-kw research reactor at Raleigh, N.C., was started up in 1953 and was dismantled in 1955. The reactor was reactivated with a 500-watt core in March 1957. Early in 1959, the reactor was modified for 100-watt operation and moved to a new location in the Nuclear Science Laboratory, and a new 10-kw heterogeneous-core Argonaut type reactor was built in the original RRR shield vacated by the homogeneous core.

[32] Reactors in the Army power program are identified by symbolic nomenclature to reflect mobility characteristics, power range, development sequence, and field sequence. The first capital letter indicates mobility characteristics: S (stationary operation), not designed for subsequent relocation; P (portable) semimobile, stationary operation, capable of being dismantled and reassembled for use in successive locations; M (mobile), capable of being moved intact, or virtually intact, for use in successive locations. The second capital letter indicates the power range, as measured by design

[38] PL-3 will produce 1.5 million BTU of steam per hour to operate [illegible] equipment to supply fresh water.

[40] HTRE-1 was partially dismantled in 1957. It could be made operable again if desired, but there are no present plans to do so.

[41] With the termination of the Aircraft Nuclear Propulsion program early in 1961, these reactors have been placed on a stand-by status.

[42] Upon completion of construction and after initial start-up and checkout for proper operation, the NETR will be placed on a stand-by status.

[43] The design of this reactor incorporates features making possible conversion to permit power take-off.

[44] This is the 1955 Geneva Conference reactor rebuilt with increased power and now operating at Wuerenlingen, Switzerland.

[45] The Venezuela Research Reactor was shut down in September 1961. It is ex-

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run on December 21 and 22, 1951, EBR-I generated the world's first electric power from nuclear energy. Criticality with the third core was achieved in November 1957. A plutonium bearing core (Mark IV) has been fabricated and will be loaded in the reactor in 1962.

[15] This reactor experiment utilizes technology developed under the Aircraft Nuclear Propulsion Program, which was cancelled early in 1961.

[28] After the assembly and operation of this reactor in the Government exhibit at Geneva in September 1958, it was dismantled and returned to ANL, where it is being rebuilt as a 250-kw(t) Juggernaut.

[29] This reactor was shipped abroad for exhibition purposes in Pakistan and Egypt in 1960.

[31] The original 10-kw research reactor at Raleigh, N.C., was started up in 1953 and was dismantled in 1955. The reactor was reactivated with a 500-watt core in March 1957. Early in 1959, the reactor was modified for 100-watt operation and moved to a new location in the Nuclear Science Laboratory, and a new 10-kw heterogeneous-core Argonaut type reactor was built in the original RRR shield vacated by the homogeneous core.

[32] Reactors in the Army power program are identified by symbolic nomenclature to reflect mobility characteristics, power range, development sequence, and field sequence. The first capital letter indicates mobility characteristics: S (stationary operation), not designed for subsequent relocation; P (portable) semimobile, stationary operation, capable of being dismantled and reassembled for use in successive locations; M (mobile), capable of being moved intact, or virtually intact, for use in successive locations. The second capital letter indicates the power range, as measured by design capacity for continuous operation: L (low), 100 to 1000 kw(e); M (medium) 1000 to 10,000 kw(e), H (high): 10,000 kw(e) or more. Arabic numerals indicate order in which plants having the same mobility and power characteristics are initiated. If not followed by an additional letter, the designation indicates a prototype or pilot plant. The last capital letter (when present) indicates the alphabetical order in which field plants of a specific type are initiated.

[33] PM-2A will produce 1 million Btu/hr. in the form of steam for space heating and snow melting in addition to electrical output.

[34] SM-1A, formerly known as APPR-1A, will produce 38 million Btu/hr. for space heat in addition to electrical output.

[35] All reactors in the naval propulsion program are of the pressurized-water type except the sodium-cooled system formerly installed in the *Seawolf*. Symbols in the type column indicate (1) the ship type for which the reactor is designed, (2) the sequence number of the plant design by the principal contractor for each ship type, and (3) the designator letter for the name of the contractor responsible for the design of the reactor plant. When appearing as the first letter of the symbol, S indicates submarine; D, destroyer; C, cruiser; and A, large surface ship. The principal-contractor designation letters are W for Westinghouse, G for General Electric, and C for Combustion Engineering.

[36] USS *Seawolf*, originally commissioned with a sodium-cooled reactor in March 1957, was recommissioned with a pressurized-water reactor on September 30, 1960.

[37] SL-1 was designed to produce 1.3 million Btu/hr. of space heat in addition to electrical output; the additional output was dissipated through a heat pump. A nuclear criticality accident occurred on January 3, 1961. Dismantling the reactor is in progress.

[39] PL-3 will produce 1.5 million BTU of steam per hour to operate snow-melting equipment to supply fresh water.

[40] HTRE-1 was partially dismantled in 1957. It could be made operable again if desired, but there are no present plans to do so.

[41] With the termination of the Aircraft Nuclear Propulsion program early in 1961, these reactors have been placed on a stand-by status.

[42] Upon completion of construction and after initial start-up and checkout for proper operation, the NETR will be placed on a stand-by status.

[43] The design of this reactor incorporates features making possible conversion to permit power take-off.

[44] This is the 1955 Geneva Conference reactor rebuilt with increased power and now operating at Wuerenlingen, Switzerland.

[45] The Venezuela Research Reactor was shut down in September 1961. It is expected that the reactor will not be operated until 1964-65.

[46] The Netherlands research reactor was originally operated at the Amsterdam International Exhibition in June 1957; major portions of the exhibition reactor system were used to fabricate the present reactor.

[47] This TRIGA reactor was operated at the 1958 International Conference in Geneva prior to shipment to the University of Lovanium. The reactor began operating at the University of Lovanium in June 1959. It is the first reactor to be operated on the African continent.

[48] This L-77 reactor was operated in the commercial exhibit of the 1958 International Conference in Geneva. It is presently in storage without fuel at Interatom, Inc.

[49] AGN 201-111 was operated in the commercial exhibit of the 1958 International Conference in Geneva prior to transfer to the University of Geneva.

[50] This reactor was operated in the International Science Section of the Brussels International Exhibition, April 15 to October 1, 1958, prior to transfer to the University of Basel.

[51] Zero-power experiments of historical interest previously conducted in ANL facility cells include the *Nautilus* core design (ZPR-1), the Savannah River reactor design (ZPR-2), and a series of fast-neutron studies (ZPR-4) and interactions between two basic systems (ZPR-5). The following experiments have been performed in the ZPR-7 facility: thorium, uranium, deuterium criticals (THUD), and a series of flux-trap criticals for the Argonne High Flux Research Reactor.

[52] B&W cells 2 and 3 share a control panel; only one cell can be operated at any one time.

[53] The cell has one control panel but two pots. Experiments may be operated in either pot, but not simultaneously.

APPENDIX 11

Reactors Under Active Design or Construction June 30, 1960, and June 30, 1961

Civilian Power Prototypes and Experiments

Number of Projects for Quarter Ended 6/30/60	6/30/61	
1	1	CVTR (Carolinas-Virginia Tube Reactor)
2	--	Florida West Coast Nuclear Group
3	2	Enrico Fermi—Power Reactor Development Co.
4	3	Hallam—Consumers Public Power District of Nebraska
5	4	Pathfinder—Northern States Power Co.
6	5	City of Piqua
7	6	Elk River—Rural Cooperative Power Association
8	--	Yankee Atomic Electric Co.
9	7	Humboldt Bay—Pacific Gas and Electric Co.
10	--	Dresden—Commonwealth Edison Co.
11	8	Indian Point—Consolidated Edison Co.
12	9	EBR-2
13	10	EGCR (Experimental Gas Cooled Reactor)
14	11	Peach Bottom—Philadelphia Electric Co.
15	12	UHTRE* (Ultra High Temperature Reactor Experiment)
16	13	LAMPRE-1
17	14	EBWR Modifications
18	15	PWR Modifications
19	16	Saxton Nuclear Reactor Project
20	17	EOCR (Experimental Organic Cooled Reactor)
21	18	BONUS—Puerto Rico Water Resources Authority
22	19	Big Rock Point—Consumers Power Co.
23	20	BORAX-5 (Modification of BORAX-4)
--	21	EBOR (Experimental Beryllium Oxide Reactor)
--	22	MSRE (Molten Salt Reactor Experiment)
--	23	Vallecitos Experimental Superheat Reactor
--	24	LaCrosse Boiling Water Reactor

*formerly TURRET

Civilian Testing

1	1	Plum Brook—National Aeronautics and Space Agency
2	--	WTR—Westinghouse Testing Reactor
3	2	JANUS (Biological Research Reactor—ANL)
4	3	HWCTR—Heavy Water Components Test Reactor
5	4	PRTR—Plutonium Recycle Test Reactor
6	--	SPERT-2
7	5	SPERT-4
--	6	ATR (Advanced Test Reactor)
--	7	Fast Burst Reactor

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Number of Projects for Quarter Ended 6/30/60	6/30/61	
1	1	Brookh
2	2	Juggern
3	--	Puerto
4	3	Texas A
5	--	Ohio St
6	--	Univers
7	--	Univers
8	4	Univers
9	--	Univers
10	5	Walter
11	6	Washin
12	7	Georgia
13	8	Union
14	9	Cornell
15	10	Univer
16	11	Univer
17	--	Univer
18	12	High F
19	--	Univer
20	--	Univer
21	--	GDC F
22	--	Lockhe
23	13	Ames I
--	14	Purdue
--	15	NASA
--	16	Univer
--	17	Northr
--	18	Colum
--	19	Univer
--	20	NBSR
1	1	NS Sa

Military Pr

1	1	Destro
2	2	Mobil
3	3	Portal
4	--	Porta
		Gre
5	4	Static
		Ala
--	5	Porta
--	6	Natur

Civilian Research and Teaching

Number of Projects Quarter Ended 3/30/60	6/30/61	
1	1	Brookhaven High Flux Beam Research Reactor
2	2	Juggernaut (ANL)
3	--	Puerto Rico Nuclear Center Research Reactor
4	3	Texas A&M Research Reactor
5	--	Ohio State University Research Reactor
6	--	University of Virginia Research Reactor
7	--	University of California at Los Angeles
8	4	University of Kansas Research Reactor
9	--	University of Washington Research Reactor
10	5	Walter Reed Medical Center
11	6	Washington State University Research Reactor
12	7	Georgia Tech Research Reactor
13	8	Union Carbide Research Reactor (Sterling Forest, N.Y.)
14	9	Cornell TRIGA Reactor
15	10	University of Missouri (School of Mines)
16	11	University of Buffalo
17	--	University of Illinois
18	12	High Flux Isotope Reactor (ORNL)
19	--	University of Wisconsin
20	--	University of Maryland
21	--	GDC Flair Facility (TRIGA MARK F)
22	--	Lockheed Nuclear Products Training Reactor
23	13	Ames Laboratory Research Reactor
--	14	Purdue University
--	15	NASA Mock-Up Reactor
--	16	University of Missouri
--	17	Northrop Corp. (Space Radiation Laboratory)
--	18	Columbia University
--	19	University of Texas
--	20	NBSR (Bureau of Standards)

Merchant Ship Propulsion

1	1	NS Savannah

Military Prototypes, Experiments, and Field Plants

1	1	Destroyer Reactor Prototype (D1G) West Milton, N.Y.
2	2	Mobile Low Power Plant (ML-1) NRTS
3	3	Portable Medium Power Plant (PM-1) Sundance, Wyoming
4	--	Portable Medium Power Plant (PM-2A) Camp Century, Greenland
5	4	Stationary Medium Power Plant (SM-1A) Fort Greely, Alaska
--	5	Portable Medium Power Plant (PM-3A) McMurdo Sound
	6	Natural Circulation Test Plant (S5G) NRTS

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Military Testing and Research

Number of Projects for Quarter Ended 6/30/60	6/30/61	
1	--	Nuclear Test Plant (Army—NRTS)
2	1	SERF—Sandia Engineering Reactor Facility
3	2	NETR—Nuclear Engineering Test Reactor (USAF—Dayton, Ohio)
4	--	Materials Research Reactor (USA—Watertown Arsenal)
5	3	Ordnance Pulsed Experimental Research Assembly (USA)
6	4	SPRF—Sandia Pulsed Reactor Facility
--	5	Diamond Ordnance Fuse Laboratory Radiation Facility (USA)
--	6	National Naval Medical Center

Materials Production

1	1	NPR—New Production Reactor

Note: Projects are *added* to this tabulation:

(1) During the calendar quarter in which license applications are received.

(2) For projects under the cooperative demonstration program, during the quarter in which a basis for arrangements is submitted to the JCAE.

(3) For Government projects not subject to licensing and not subject to the submission of a basis for arrangements to the JCAE, during the quarter in which Title I work begins. (However, Government projects are not added prior to a decision to proceed with construction at a specific location even though design work may be underway.)

Projects are *dropped* from this tabulation in the quarter following the calendar quarter in which they first operate at design power.

Modifications to existing projects are included only when a substantial increase in the rated power output will result.

APPENDIX 12

Operable Foreign Reactors and Assemblies Subject to U.S. Safeguards as of November 30, 1961

57 REACTORS AND CRITICAL ASSEMBLIES IN 24 COUNTRIES

Country	Facility name	Type	Site	Fuel enrich-	Thermal	Reason for safeguards	Inspection	Inspections

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APPENDIX 12

Operable Foreign Reactors and Assemblies Subject to U.S. Safeguards as of November 30, 1961

57 REACTORS AND CRITICAL ASSEMBLIES IN 24 COUNTRIES

Country	Facility name	Type	Site	Fuel enrichment—%	Thermal power	Reason for safeguards			Inspection frequency*	Inspections
						U.S. fuel	U.S. built	U.S. heavy water		
Argentina	RA-I	Argonaut	Buenos Aires	20	10 KW	X			1/yr	2/58, 12/60
Australia	HIFAR	Dido	Sydney	90	10 MW			X	1/yr	3/60, 4/61
	MOATA	Argonaut	Sydney	20	10 KW	X	X		1/yr	4/61
Austria	ASTRA	Pool	Seibersdorf	90	12 MW	X	X		2/yr	None
Belgium	BR-0-2	Crit. Assem.	Mol	90	50 KW	X			1/yr	1/60, 3/61
	BR-2	Tank	Mol	90	50 MW	X			1/yr	1/60, 3/61
Brazil		Pool	Sao Paulo	20	5 MW	X	X		1/yr	2/58, 2/60
		TRIGA	Belo Horizonte	20	30 KW	X	X		Nominal	12/60
China, Rep. of	CRR	Pool	Hsin-Chu	20	1 MW	X	X		1/yr	4/61
Congo	TRICO	TRIGA	Leopoldville	20	10 KW	X	X		Nominal	None
Denmark	DR-1	Aq. Homo. L-55	Risø	20	500 W	X	X		Nominal	11/57, 5/59, 5/61
	DR-2	Pool-Tank	Risø	90	5 MW	X	X		3/yr	5/59, 5/60, 5/61
	DR-3	Pluto	Risø	90	10 MW			X	1/yr	5/59, 5/60, 5/61

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Operable Foreign Reactors and Assemblies Subject to U.S. Safeguards as of November 30, 1961—Con.

57 REACTORS AND CRITICAL ASSEMBLIES IN 24 COUNTRIES—Con.

Country	Facility name	Type	Site	Fuel enrichment—%	Thermal power	Reason for safeguards			Inspection frequency*	Inspections
						U.S. fuel	U.S. built	U.S. heavy water		
France	EL-3	Tank-D_2O	Saclay	1.6	15 MW	X			1/yr	10/58, 1/60, 3/61
	ALIZE/RUBEOLE	Crit. Facility	Saclay	3.5	0	X			Nominal	10/58, 1/60, 3/61
	PROSERPINE	Aq. Homo. Pu & U	Saclay	1.5	1 W	X			Nominal	3/61
	AQUILON	Res. Reactor	Saclay	Natural	1 W			X	Nominal	3/61
	MELUSINE	Pool	Grenoble	20	1 MW	X			1/yr	10/58, 1/60, 3/61
	TRITON I & II	Pool	Fontenay	20	1 MW	X			1/yr	1/60, 3/61
	MINERVE	Pool	Fontenay	20	100 W	X			1/yr	1/60, 3/61
	PEGGY	Pool	Saclay	20	0	X			1/yr	3/61
Germany	FRM	Pool	Munich	20	1 MW	X	X		1/yr	10/58, 1/60, 3/61
	SAR	Argonaut	Munich	20	10 KW	X		X	1/yr	1/60, 3/61
	FR-2	Tank Nat U D_2O	Karlsruhe	Natural	12 MW			X	1/yr	1/60, 3/61
	FRF	Aq. Homo	Frankfurt	20	50 KW	X	X		Nominal	10/58, 1/60
	FRB	Aq. Homo	W. Berlin	20	50 KW	X	X		Nominal	10/58, 1/60
	FRG	Pool	Hamburg	20	5 MW	X	X		1/yr	10/58, 1/60, 3/61
	RWE	BWR-Power	Kahl am Main	2.5	60 MW	X	X		3/yr	3/61
	AEG	Argonaut	Grosswelzheim	20	10 KW	X	X		1/yr	3/61
Greece	GRR	Pool	Athens	20	1 KW	X	X		1/yr	8/61
India	ZERLIMA	Crit. Assem	Trombay	Natural	0			X	Nominal	None
Israel	IRR	Pool	Rehovoth	90		X	X		2/yr	6/60, 8/61
Italy	RS-1	Pool	Saluggia	20	5 MW	X	X		1/yr	6/59, 5/60, 8/61
	ISPRA-I & II	CP-5	Ispra	20/90	5 MW	X	X	X	2/yr	6/59, 5/60, 8/61
		Aq. Homo. L-54	Milan	20	50 KW	X	X		Nominal	6/59, 5/60
	CNRN	TRIGA Mk II	Rome	20	100 KW	X	X		Nominal	8/61
		AGN-201	Palermo	20	20 W	X	X		Nominal	8/61
		Sub. Critical	Univ. of Cagliari	Natural	0	X			Nominal	None
	AGIP	Argonaut	San Donato	20	10 KW	X			1/yr	8/61
	CAMEN	Pool	Livorno	90	3-5 MW	X	X		1/yr	8/61
Japan	JRR-1	Aq. Homo	Tokai-Mura	20	50 KW	X	X		Nominal	3/60, 8/57
	JRR-2	CP-5	Tokai-Mura	20	10 MW	X	X	X	1/yr	3/60, 4/61
		Semi-Homo. C.A	Tokai-Mura	20	0	X			1/yr	3/60, 4/61
		Fast Neut. Con	Tokai-Mura	20	0	X			1/yr	None
Korea	KRR	TRIGA MK II	Seoul	20	100 KW	X	X		Nominal	4/61

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Italy	RS-1	Pool	Saluggia	20	5 MW	X	X		1/yr	6/59, 5/60, 8/61
	ISPRA-I & II	CP-5	Ispra	20/90	5 MW	X	X	X	2/yr	6/59, 5/60, 8/61
		Aq. Homo. L-54	Milan	20	50 KW	X	X		Nominal	6/59, 5/60
	CNRN	TRIGA Mk II	Rome	20	100 KW	X	X		Nominal	8/61
		AGN-201	Palermo	20	20 W	X	X		Nominal	8/61
		Sub. Critical	Univ. of Cagliari	Natural	0	X			Nominal	None
	AGIP	Argonaut	San Donato	20	10 KW	X			1/yr	8/61
	CAMEN	Pool	Livorno	90	3-5 MW	X	X		1/yr	8/61
Japan	JRR-1	Aq. Homo	Tokai-Mura	20	50 KW	X	X		Nominal	3/60, 8/57
	JRR-2	CP-5	Tokai-Mura	20	10 MW	X	X	X	1/yr	3/60, 4/61
		Semi-Homo. C.A	Tokai-Mura	20	0	X			1/yr	3/60, 4/61
		Fast Neut. Con	Tokai-Mura	20	0	X			1/yr	None
Korea	KRR	TRIGA MK II	Seoul	20	100 KW	X	X		Nominal	4/61
Netherlands	LFR	Argonaut	Petten	90	100 KW	X			1/yr	5/61
Norway	HBWR	Boiling Water	Halden	1.5	10 MW	X		X	Nominal	5/59, 5/60, 5/61
	NORA	Nat U Pool	Kjeller	Natural	100 W			X	Nominal	None
Portugal		Pool	Sacavem	20	1 MW	X	X		1/yr	9/61
Spain	JEN-1	Pool	Moncloa	20	3 MW	X	X		1/yr	6/59, 6/60, 9/61
Sweden	R-2-O	Pool	Studsvik	90	100 KW	X			1/yr	5/61
Switzerland	SAPHIRE	Pool	Wurenlingen	20	1 MW	X	X		1/yr	6/59, 5/60, 9/61
	ALADIN	AGN-201	Geneva	20	20 W	X	X		Nominal	6/59
		AGN-211	Basel	20	1 KW	X	X		Nominal	6/59
	DIORIT	Nat. U	Wurenlingen		12 MW			X	1/yr	9/61
Turkey	TRR	Pool	Kucmece	90	1 MW	X	X		1/yr	8/61
Venezuela	RV-1	Pool	Caracas	20	3 MW	X	X		1/yr	12/60

Total reactors subject to safeguards—57
Number of facilities inspected 1961—41
Number of countries inspected 1961—18

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APPENDIX 13

Foreign Research Reactor Grants

Total Grants 23 (May 30, 1956–December 31, 1961)

Country	Type	Power (thermal)	Manufacturer	Estimated project cost (millions)
Austria, Vienna [1]	Tank	5 MW [3]	American Machine and Foundry	[illegible]
Belgium, Mol [1]	Tank	25 MW [2]	Centre d'Etudes de l'Energie Nucleaire. Nuclear Development Associates.	[illegible]
Brazil, Sao Paulo [1]	Pool	5 MW	Babcock and Wilcox	[illegible]
China, Hsinchius [1]	Pool	1 MW	International General Electric	1.3
Denmark, Risoe [1]	Tank	5 MW	Foster-Wheeler	1.6
Greece, Aghia Paraskeri [1]	Pool	1 MW	American Machine and Foundry	1.4
Indonesia, Bandung [4]	Tank	100 KW	General Atomic	1.3
Israel, Nahal Sorek [1]	Pool	1 MW	American Machine and Foundry	0.8
Italy, Ispra [1]	Tank	5 MW	American Car and Foundry	1.4
Japan, Tokaimura [1]	Tank	10 MW	American Machine and Foundry	3.6
Korea, Alyang	Tank	100 KW	General Atomic	1.5
Netherlands, Petten	Tank	20 MW	American Car and Foundry	1.1
Norway, Kjeller [1]	Pool	10 KW	Norstom	3.9
Pakistan, Rawalpindi	Pool	5 MW	American Machine and Foundry	0.8
Portugal, Lisbon [1]	Pool	1 MW	American Machine and Foundry	3.5
Spain, Madrid [1]	Pool	3 MW	International General Electric	1.0
Sweden, Studsvik	Tank	30 MW	American Car and Foundry	1.0
Thailand, Bangkok	Pool	1 MW	Curtiss-Wright	4.3
Turkey, Istanbul	Pool	1 MW	American Machine and Foundry	[illegible]
Venezuela, Caracas [1]	Pool	3 MW	International General Electric	[illegible]
Vietnam, Dalat	Tank	100 MW	General Atomic	0.75
West Germany, Munich [1]	Pool	1 MW	American Machine and Foundry	3.1
Yugoslavia, Ljubljana	Tank	100 KW	General Dynamics	0.812

[1] Grant paid.
[2] Convertible to 50 MW.
[3] Convertible to 12 MW.
[4] Commission approved grant during 1961.

Materials

1

Date	Country
7, 1960	Argentina
11, 1960	Canada
15, 1960	West Germany
17, 1960	United Kingdom
19, 1960	France
19, 1960	France
19, 1960	France
19, 1960	France
20, 1960	West Germany
20, 1960	Venezuela
28, 1960	Rep. of China
4, 1961	France
4, 1961	France
4, 1961	France
4, 1961	France
6, 1961	United Kingdom
6, 1961	United Kingdom
9, 1961	Italy
13, 1961	Netherlands
7, 1961	Rep. of China
7, 1961	Rep. of China
13, 1961	Australia
21, 1961	Italy
21, 1961	Belgium
28, 1961	Canada
28, 1961	Canada
1, 1961	France
6, 1961	Norway
8, 1961	Turkey
9, 1961	Australia
10, 1961	Austria
10, 1961	Belgium
17, 1961	West Germany
23, 1961	Switzerland
23, 1961	Italy
23, 1961	Japan
24, 1961	Portugal
24, 1961	Belgium
24, 1961	Canada
28, 1961	Norway
29, 1961	France
30, 1961	France
3, 1961	Japan
20, 1961	France
20, 1961	France
21, 1961	West Germany
21, 1961	Netherlands

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	Estimated project cost (millions)
dry	$4.0
Nucleaire.	10.01
ciates.	
	1.3
	1.0
	1.4
dry	1.3
	0.8
	1.4
dry	3.6
	1.5
	1.1
	3.9
	0.8
dry	3.5
dry	1.0
	1.0
	4.3
	0.82
dry	2.88
	5.0
	0.75
dry	3.1
	0.812

APPENDIX 14

Materials Shipments to Foreign Countries

December 1960–November 1961

Date	Country	Uranium U-235	Uranium Percent enrich.	Other materials	Type of transaction	Purpose and remarks
7, 1960	Argentina			Depl U 2,040 gms.	Sale	Research.
11, 1960	Canada	gms 124	20		Sale	Research.
15, 1960	West Germany	gms 1	90		Sale	NBS Standard.
17, 1960	United Kingdom			PU 199 gms	Loan	TNCC
19, 1960	France	gms 3,082	20		Lease	Research
19, 1960	France	gms 5,103	20		Lease	Research.
19, 1960	France	gms 800	90		Lease	Research.
19, 1960	France	gms 5	90		Sale	Fission Counter.
20, 1960	West Germany	gms 24	90		Sale	Research.
20, 1960	Venezuela			PU 10 gms	Sale	Source.
28, 1960	Rep. of China	gms 30	90		Sale	Research.
4, 1961	France			PU 501 gms	Sale	Research.
4, 1961	France	gms 3,021	20		Lease	Store.
4, 1961	France	gms 1,447	4		Lease	Research.
4, 1961	France	gms 1,437	8		Lease	Research.
6, 1961	United Kingdom			Normal U*	Sale	Research.
6, 1961	United Kingdom	gms .09	90		Loan	Research.
9, 1961	Italy	gms 19.76	20		Sale	Research.
13, 1961	Netherlands	gms 1,731.83	90		Lease	Research.
7, 1961	Rep. of China	gms 4,745	20		Lease	Fission Counter.
7, 1961	Rep. of China	gms 1.50	90		Sale	Research.
13, 1961	Australia			D_2O 125 lbs	Sale	Research.
21, 1961	Italy	gms 184.86	20		Lease	Research.
21, 1961	Belgium	gms 2,439	90		Lease	Fuel BR-2.
28, 1961	Canada	gms .12	20		Sale	NBS Standards.
28, 1961	Canada			Depl U*	Sale	NBS Standards.
1, 1961	France	gms 672.75	20		Sale	MTR Type Elements.
6, 1961	Norway			D_2O 998 lbs	Sale	Process Heat.
8, 1961	Turkey			Normal U 2,493.59 kgs.	Sale	Research.
9, 1961	Australia	gms 3,176	90		Lease	Research.
10, 1961	Austria			PU*	Sale	Research.
10, 1961	Belgium			U-233 10.01 gms	Sale	Research.
17, 1961	West Germany			Depl U 100 gms	Sale	Research.
23, 1961	Switzerland			PU 159.88 gms	Sale	Research.
23, 1961	Italy	(*)	90		Sale	Research.
23, 1961	Japan	gms 537	20		Lease	Research.
24, 1961	Portugal	gms 5,751.19	20		Lease	Research.
24, 1961	Belgium	gms 7,234.8	90		Lease	Fuel for BR-2.
24, 1961	Canada	gms 6,133	90		Lease	Fuel for NRX React.
28, 1961	Norway			PU 0.50 gms	Sale	Research.
29, 1961	France	gms 316.62	20		Lease	Research.
30, 1961	France	gms 259	90		Lease	Research.
3, 1961	Japan	gms 3,102.47	20		Lease	Research.
20, 1961	France			U-233 57.74 gms	Lease	Research.
20, 1961	France	gms 49.04	90		Loan	EANDC.
21, 1961	West Germany	gms 99.98	90		Sale	Research.
21, 1961	Netherlands	gms 2,920	90		Sale	Research.

See footnote at end of table.

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Materials Shipments to Foreign Countries—Continued

December 1960–November 1961—Continued

Date	Country	Uranium		Other materials	Type of transaction	Purpose and remarks
		U-235	Percent enrich.			
Apr. 25, 1961	Switzerland			D_2O 3,992 lbs	Sale	Test & Research.
Apr. 28, 1961	France	gms 100.04	90		Sale	Research.
Apr. 30, 1961	Netherlands	gms .93	90		Sale	NBS Standards.
May 3, 1961	Sweden	gms 8.60	90		Sale	Fission Counter.
May 9, 1961	Canada	gms 977.31	90		Lease	NRU Reactor.
May 15, 1961	France	gms 1,200.14	20		Lease	Research.
May 17, 1961	West Germany	gms 1,000	20		Lease	Research.
May 19, 1961*	Japan			U_3O_8 Concentrate 17,819 lbs.	Sale	
May 24, 1961	Israel			U-233 5 gms	Sale	Research.
May 24, 1961	West Germany	gms 376.61	2		Sale	Research.
May 25, 1961	S. Korea			PU 7.95 gms	Sale	Research.
May 26, 1961	New Zealand			Normal U 2,493.50 kgs.	Sale	Research.
May 31, 1961	France			Depl U*	Sale	NBS Standards.
May 31, 1961	Israel	gms 9.32	90		Sale	NBS Standards.
May 31, 1961	France	gms .92	20		Sale	NBS Standards.
June 2, 1961	United Kingdom			U-233 511.18 gms.	Sale	Exchange.
June 2, 1961	West Germany	gms 777.20	20		Sale	Sub-Critical Exp.
June 5, 1961	France	gms 776.32	90		Lease	Research.
June 5, 1961	Israel	gms 8.77	90		Sale	Research.
June 5, 1961	France	gms 200	90		Lease	Research.
June 7, 1961	Japan	gms 2,000	20		Lease	Research.
June 7, 1961	Denmark	gms 1.32	90		Sale	Research.
June 8, 1961	Australia			D_2O 998 lbs	Sale	Research.
June 15, 1961	Euratom			PU 998 gms	Sale	Dist. to France & Belgium
June 20, 1961	Belgium	gms 3,775.95	5		Lease	Research.
June 23, 1961	West Germany			PU 4,559 gms	Sale	Research.
June 23, 1961	West Germany	gms 5,998	20		Lease	Research.
June 26, 1961	Sweden	gms 5,046.97	90		Lease	Test Reactor.
June 26, 1961	Sweden	gms 776.32	90		Lease	Test Reactor.
June 27, 1961	Italy	gms 6,112.81	90		Lease	Research.
June 30, 1961	Israel			Normal U 20 gms.	Sale	NBS Standard.
June 30, 1961	France	gms 1,099.89	90		Lease	Store.
June 30, 1961	France	gms 6.03	90		Sale	NBS Standard.
June 30, 1961	France			Depl U*	Sale	NBS Standard.
June 30, 1961	France			Normal U 20 gms.	Sale	NBS Standard.
June 30, 1961	Canada			Normal U 170 gms.	Sale	NBS Standard.
June 30, 1961	Canada			Normal U 20 gms.	Sale	NBS Standard
June 30, 1961	France	gms 642.80	1.6		Lease	Fuel Fabrication.
June 30, 1961	France	gms 1.12	20		Sale	NBS Standard.
June 30, 1961	France	gms 4,610.66	20		Lease	Store.
July 3, 1961	Japan			D_2O 661 lbs	Sale	Research.
July 10, 1961	France	gms 10	90		Sale	Research
July 11, 1961	France	gms 3,222	3		Lease	Store.
July 11, 1961	France	gms 1,328	90		Lease	Store.
July 11, 1961	Netherlands	gms 4,688.13	90		Lease	Research.
July 12, 1961	Netherlands	gms 838.13	90		Lease	Research.

See footnote at end of table

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Date	Country
uly 12, 1961	France
uly 14, 1961	Greece
uly 15, 1961	Greece
uly 18, 1961	Belgium
uly 20, 1961	Belgium
uly 25, 1961	Canada
uly 27, 1961	West Germany
uly 31, 1961	Belgium
ug. 1, 1961	Sweden
ug. 3, 1961	Japan
ug. 3, 1961	Norway
ug. 10, 1961	Sweden
ug. 11, 1961	Netherlands
ug. 15, 1961	Canada
ug. 17, 1961	West Germany
ug. 21, 1961	New Zealand
ug. 24, 1961	France
ug. 25, 1961	France
ug. 28, 1961	United Kingdo
ug. 31, 1961	Netherlands
ept. 11, 1961	Australia
ept. 11, 1961	Australia
ept. 11, 1961	France
ept. 13, 1961	France
ept. 13, 1961	Israel
ept. 13, 1961	Israel
ept. 13, 1961	Turkey
ept. 14, 1961	Belgium
ept. 14, 1961	Turkey
ept. 15, 1961	Turkey
ept. 15, 1961	Lebanon
ept. 15, 1961	Lebanon
ept. 18, 1961	Italy
ept. 20, 1961	Canada
ept. 25, 1961	Austria
ept. 28, 1961	Portugal
Oct. 6, 1961	South Korea
Oct. 12, 1961	Switzerland
Oct. 13, 1961	Canada
Oct. 16, 1961	Japan
Oct. 16, 1961	IAEA
Oct. 19, 1961	Japan
Oct. 19, 1961	United Kingdo
Oct. 20, 1961	Japan
Oct. 23, 1961	Canada
Oct. 24, 1961	West Germany
Oct. 26, 1961	Netherlands
Nov. 2, 1961	Canada
Nov. 2, 1961	Italy
Nov. 2, 1961	Japan
Nov. 3, 1961	Japan
Nov. 6, 1961	Italy

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MATERIALS SHIPMENTS TO FOREIGN COUNTRIES—Continued

December 1960–November 1961—Continued

Date	Country	Uranium U-235	Uranium Percent enrich.	Other materials	Type of transaction	Purpose and remarks
ly 12, 1961	France	gms 7,053.88	90		Lease	Research.
ly 14, 1961	Greece	gms 0.69	20		Lease	2 Fission Counters.
ly 15, 1961	Greece	gms 5,981.27	20		Lease	Research.
ly 18, 1961	Belgium			PU 0.68 gms	Sale	Research.
ly 20, 1961	Belgium	gms 7,558.07	9		Sale	Research.
ly 25, 1961	Canada	gms 1,123.01	90		Lease	NRX Reactor.
ly 27, 1961	West Germany			U-233 0.01 gm	Sale	Research.
ly 31, 1961	Belgium	gms 0.25	20		Sale	NBS Standard.
ug. 1, 1961	Sweden			PU*	Loan	Research.
ug. 3, 1961	Japan	gms 4,740	10		Lease	Research.
ug. 3, 1961	Norway	gms 3,750	1.7		Sale	Research.
ug. 10, 1961	Sweden			PU 57.56 gms	Sale	Research.
ug. 11, 1961	Netherlands	gms 4,424.50	20		Lease	Research.
ug. 15, 1961	Canada	gms 1,563.49	90		Lease	NRU Reactor.
ug. 17, 1961	West Germany			D_2O 24,152 lbs	Sale	DIDO Reactor.
ug. 21, 1961	New Zealand			PU 80 gms	Sale	Research.
ug. 24, 1961	France	gms 3,009	20		Lease	Store.
ug. 25, 1961	France	gms 389.14	20		Lease	Store.
ug. 28, 1961	United Kingdom			PU 91.40 gms	Gift	Sample Exchange.
ug. 31, 1961	Netherlands	gms 5,405.53	90		Lease	Research.
ept. 11, 1961	Australia			PU 160 gms	Sale	Source.
ept. 11, 1961	Australia			PU 160 gms	Sale	Source.
ept. 11, 1961	France	gms 402	90		Lease	Research.
ept. 13, 1961	France	gms 688.52	90		Lease	Research.
ept. 13, 1961	Israel	gms 3.30	90		Sale	NBS Standard.
ept. 13, 1961	Israel	gms .93	10		Sale	NBS Standard.
ept. 13, 1961	Turkey			PU 128 gms	Sale	Source.
ept. 14, 1961	Belgium	gms 99,474	4		Sale	Research.
ept. 14, 1961	Turkey	gms 1.80	90		Sale	Fission Counter.
ept. 15, 1961	Turkey	gms 4,770.96	90		Lease	Research.
ept. 15, 1961	Lebanon	gms 1,517.40	20			U.S. Exhibit.
ept. 15, 1961	Lebanon			PU 11.93 gms		U.S. Exhibit.
ept. 18, 1961	Italy	gms 2,342.62	90		Lease	Research.
ept. 20, 1961	Canada	gms 61	90		Sale	Research.
ept. 25, 1961	Austria			PU 48 gms	Lease	Source.
ept. 28, 1961	Portugal	gms 272.91	20		Lease	Research.
Oct. 6, 1961	South Korea	gms 46.53	90		Sale	Research.
Oct. 12, 1961	Switzerland	gms 3,353.17	90		Sale	Research.
Oct. 13, 1961	Canada	gms 2,855.95	90		Lease	Research.
Oct. 16, 1961	Japan	gms 3,172.93	90		Lease	Research.
Oct. 16, 1961	IAEA	gms 42,206	3		Lease	NORA Reactor (Norway).
Oct. 19, 1961	Japan	gms 2,290.29	20		Lease	Research.
Oct. 19, 1961	United Kingdom			Normal U 10 kgs.	Gift	Research.
Oct. 20, 1961	Japan	gms 542.27	20		Lease	Research.
Oct. 23, 1961	Canada			PU 32 gms	Sale	Source.
Oct. 24, 1961	West Germany	gms 7,480	90		Lease	Research.
Oct. 26, 1961	Netherlands			PU 80 gms	Sale	Source
Nov. 2, 1961	Canada			PU*	Sale	Research.
Nov. 2, 1961	Italy	gms 0.50	99		Sale	Research.
Nov. 2, 1961	Japan			D_2O 30,500 lbs	Sale	Moderator.
Nov. 3, 1961	Japan			D_2O 30,000 lbs	Sale	Moderator.
Nov. 6, 1961	Italy	gms 4,296.86	90		Lease	Fuel-Ispra.

Type of transaction	Purpose and remarks
e	Test & Research.
e	Research.
e	NBS Standards.
e	Fission Counter.
se	NRU Reactor.
se	Research.
se	Research.
---	Research.
---	Research.
---	Research.
---	Research.
---	NBS Standards.
---	NBS Standards.
---	NBS Standards.
--	Exchange.
--	Sub-Critical Exp.
e-	Research.
--	Research.
e-	Research
e-	Research.
--	Research.
--	Research.
--	Dist. to France & Belgium
-	Research.
-	Research.
-	Research.
-	Test Reactor.
-	Test Reactor.
-	Research.
-	NBS Standard.
-	Store.
-	NBS Standard.
-	NBS Standard.
-	NBS Standard.
.	NBS Standard.
.	NBS Standard
.	Fuel Fabrication.
.	NBS Standard.
.	Store.
.	Research.
.	Research
.	Store.
.	Store.
.	Research.
.	Research.

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See footnote at end of table

APPENDIX 14

MATERIALS SHIPMENTS TO FOREIGN COUNTRIES—Continued

December 1960–November 1961—Continued

Date	Country	Uranium		Other materials	Type of transaction	Purpose and remarks
		U-235	Percent enrich.			
Nov. 10, 1961	Switzerland			PU 80.00 gms	Sale	Source.
Nov. 11, 1961	Switzerland			PU 80.00 gms	Sale	Source.
Nov. 14, 1961	Euratom	gms 866.97	5.5		Sale	For France.
Nov. 16, 1961	Israel			Normal 3,000.00 kgs.	Lease	Research.
Nov. 17, 1961	Canada			Depl. U*	Sale	Research.
Nov. 21, 1961	Canada	gms 17,702.49	90		Lease	Research.
Nov. 21, 1961	Sweden	gms 4,645.57	90		Lease	Fuel for R-2.
Nov. 24, 1961	Germany	gms 3.44	90		Lease	Fission Counter.
Nov. 30, 1961	United Kingdom	gms .68	10		Sale	NBS Standard.
Nov. 30, 1961	United Kingdom	gms 4.23	90		Sale	NBS Standard.
Nov. 30, 1961	United Kingdom			Depl U*	Sale	NBS Standard.
Nov. 30, 1961	Mexico			Normal*	Sale	NBS Standard.
Nov. 30, 1961	France	gms .10	10		Sale	NBS Standard.
Nov. 30, 1961	France	gms 4.66	90		Sale	NBS Standard.
Nov. 30, 1961	France	gms 1.68	90		Sale	NBS Standard.
Nov. 30, 1961	France			Depl U*	Sale	NBS Standard.
Nov. 30, 1961	Spain			Normal*	Sale	NBS Standard.
Nov. 30, 1961	Canada			Normal*	Sale	NBS Standard.

*Amount less than reportable quantity of the reporting unit involved.

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PRESIDENTIAL DETERM

Statement

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horized use.
This action increases the
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et all foreseeable needs
A discussion of the new
the Chairman of the At

Statement by the Chairm

The President's announc
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APPENDIX 15

PRESIDENTIAL DETERMINATION INCREASING ENRICHED URANIUM ALLOTMENT

Statement by the President, September 26, 1961

rogress in using atomic energy for peaceful purposes is evident in the numer- national and international programs for scientific research and for the elopment of nuclear power and other applications. Many of the current ects and those contemplated for the future are based on the use of enriched nium. I am announcing today a further step by the United States to meet prospective needs for this material.

have determined under section 41b of the Atomic Energy Act of 1954 that amount of enriched uranium to be made available for peaceful uses at home abroad will be increased to a total of 165,000 kilograms of contained uranium Of this total, 100,000 kilograms is to be available for distribution within United States under section 53 of the Atomic Energy Act and 65,000 kilograms distribution to other countries under section 54. These amounts have been mmended by the Atomic Energy Commission with the concurrence of the retaries of State and Defense. The material will be distributed as required a period of years and will be subject to prudent safeguards against un- horized use.

This action increases the amounts of uranium 235 made available by previous erminations announced on February 22, 1956, and July 3, 1957. The new ounts are estimated to cover present commitments and those expected to made during the next few years under domestic licenses and foreign agree- nts. The purpose of this announcement is to provide continuing assurance of availability of enriched uranium for peaceful programs contemplated at me and abroad. As those programs develop in the future, it will undoubtedly necessary to make further determinations to meet their requirements. The pacity of the United States for producing enriched uranium is sufficient to et all foreseeable needs for peaceful uses in addition to our defense needs. A discussion of the new determination is contained in the attached statement the Chairman of the Atomic Energy Commission.

Statement by the Chairman, Atomic Energy Commission, September 26, 1961

The President's announcement today that the amount of enriched uranium be made available for peaceful uses at home and abroad has been increased to otal of 165,000 kilograms of contained uranium 235 is an important step in the vancement of peaceful applications of atomic energy. Of this total, the 100,000 ograms for distribution within the United States and the 65,000 kilograms for tribution to other countries were recommended by the Atomic Energy Com- ission to cover existing commitments and those expected to be made during the xt few years under domestic licenses and foreign agreements, including ma- rial for research, test, and power reactors. The availability of material for aceful uses in AEC's own facilities is not part of this determination.

The last Presidential determination was announced on July 3, 1957, and ought the total of material available to 100,000 kilograms of uranium 235, vided equally between domestic and foreign uses. As explained by the AEC at at time, the 100,000 kilogram figure was in units of equivalent output of highly riched uranium from U.S. production plants. However, most of the uranium to

nium 235 and the domestic

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licenses and foreign agreements are in terms of kilograms of uranium 235 actually contained in the material supplied. Therefore, for simplicity, the new determination is expressed in kilograms of *contained* uranium 235. The total of 165,000 kilograms of contained uranium 235 to be available is estimated as the production equivalent of about 140,000 kilograms of uranium 235 in highly enriched material, so that the new determination represents an increase of 40 percent over the previous total.

The Presidential determination of enriched uranium to be available for peaceful uses is based on anticipated needs for present projects and those expected to start during the next few years. On earlier occasions, the foreign and domestic requirements were estimated to be about equal, and thus the quantities of material determined to be available for domestic and foreign distribution were identical or nearly so. The fact that more enriched uranium presently is being made available for domestic than foreign uses reflects, for the moment at least, a somewhat more rapid increase in the domestic needs of nuclear industry for enriched uranium than in the foreign needs, but does not necessarily establish a precedent for future determinations. As new requirements for enriched uranium develop with expanded use of atomic energy at home and abroad, the quantity of material to be made available for distribution by the AEC will be reexamined periodically.

Allocation of enriched uranium to a reactor project includes material for the fuel loading, for fuel consumption over the period of the domestic license or foreign agreement, and for the "pipeline" associated with the manufacture and storage of fuel elements, cooling and shipment of irradiated fuel, and chemical processing of irradiated fuel to recover special nuclear material. The amount of uranium 235 contained in enriched uranium returned to the AEC is deducted from the amount supplied by the AEC in computing how much is available for further distribution. The material allocated to a reactor project may not be completely distributed for several decades.

As of June 30, 1961, there were in effect in the United States construction permits or operating licenses for 10 power reactors, 3 test reactors, 69 research reactors, and 14 critical-experiment facilities, in addition to 409 special nuclear material licenses for uses other than in reactors or critical-experiment facilities. Agreements for cooperation in the civil uses of atomic energy are in effect between the United States and a large part of the free world, including 38 countries and West Berlin; 14 of these agreements provide for cooperation on power reactors. In addition, agreements are in effect with the International Atomic Energy Agency and the European Atomic Energy Community (EURATOM).

Enriched uranium for peaceful purposes is distributed abroad only under agreements for cooperation in the civil uses of atomic energy. These agreements are of two general types—those providing for the transfer of modest amounts of material for research reactors and those providing substantial amounts of material for power as well as research and test reactors. All such agreements for cooperation contain a guaranty by the cooperating country that the material supplied will be used exclusively for peaceful purposes. Safeguard provisions allowing inspection of materials, facilities, and records by U.S. or international inspectors are also included, as appropriate.

The uranium 235 content of enriched uranium distributed abroad is normally limited to 20 percent. However, uranium containing up to 90 percent uranium 235 may be made available for research and test reactors and reactor experiments. Agreements providing for the transfer of such highly enriched uranium for these purposes or for the transfer of enriched uranium for power reactors contain comprehensive safeguard provisions. Agreements covering only the transfer of uranium containing up to 20 percent uranium 235 for research reactors contain more limited safeguard provisions.

COMMISSION

The Atomic Energ
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APPENDIX 16

COMMISSION'S FINANCIAL REPORT FOR FISCAL YEAR 1961

INTRODUCTION

The Atomic Energy Commission is an independent agency, responsible to the President and Congress, created in fiscal year 1947 to perform the atomic energy functions previously assigned to the Army and further to encourage the peaceful uses of atomic energy. To do this, the AEC is responsible for activities involving manufacturing, basic and applied research, and regulating the peaceful uses of atomic energy.

Funds are provided to AEC in two congressional appropriations—one for construction and one for operations. The AEC accounting system therefore must comply with the requirements of Federal Government accounting. However, since AEC is engaged in large industrial and research activities, its management requires knowledge of the cost of each step in its operations. The AEC accounting system provides this through the application of commercial accrual and cost accounting principles. For AEC, both governmental and commercial accounting have been combined into a single system. The principles of both, therefore, underlie the preparation of this report.

Most of the work involved in actually achieving the AEC goals is performed by commercial firms, or educational or other non-profit organizations under contract to the AEC. Government-owned facilities are operated by contractors who maintain complete accounting records on those activities. The report contained in the following pages is a consolidation of the contractor reports and information obtained from the AEC records. It shows the AEC assets, liabilities and equity, and the costs incurred by AEC in carrying out its responsibilities.

Costs shown in this report include depreciation unless specifically noted to the contrary.

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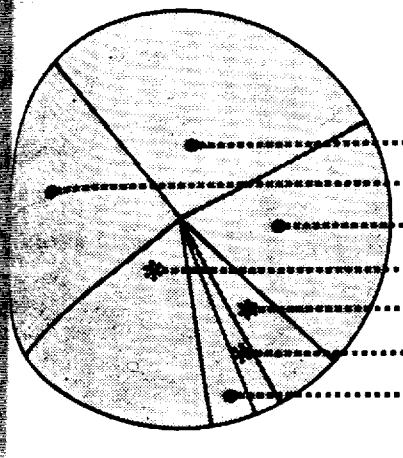
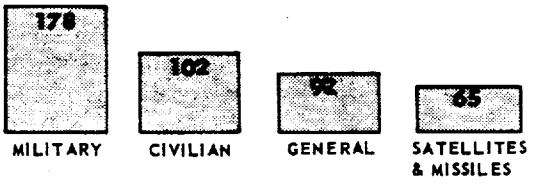
facts at a glance



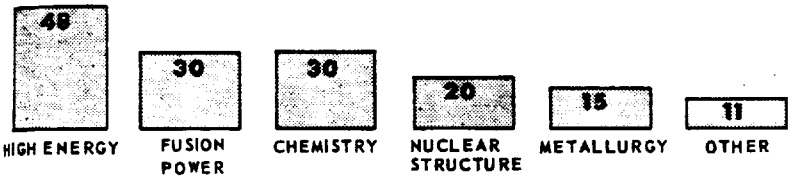
DISTRIBUTION OF 1961 OPERATIONS

millions		
$ 733	28.1%	PRODUCTION OF NUCLEAR MATERIALS
637	24.4	PROCUREMENT OF RAW MATERIALS
516	19.7	WEAPONS DEVELOPMENT & FABRICATION
437	16.7	REACTOR DEVELOPMENT
154	5.9	PHYSICAL RESEARCH
54	2.1	BIOLOGY & MEDICINE
81	3.1	OTHER
$2,612	100.0%	

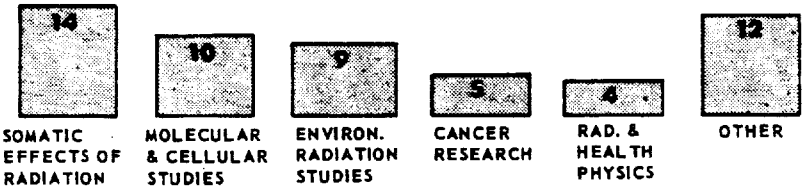
* REACTOR DEVELOPMENT ... $437 million



* PHYSICAL RESEARCH ... $154 million



* BIOLOGY AND MEDICINE ... $54 million



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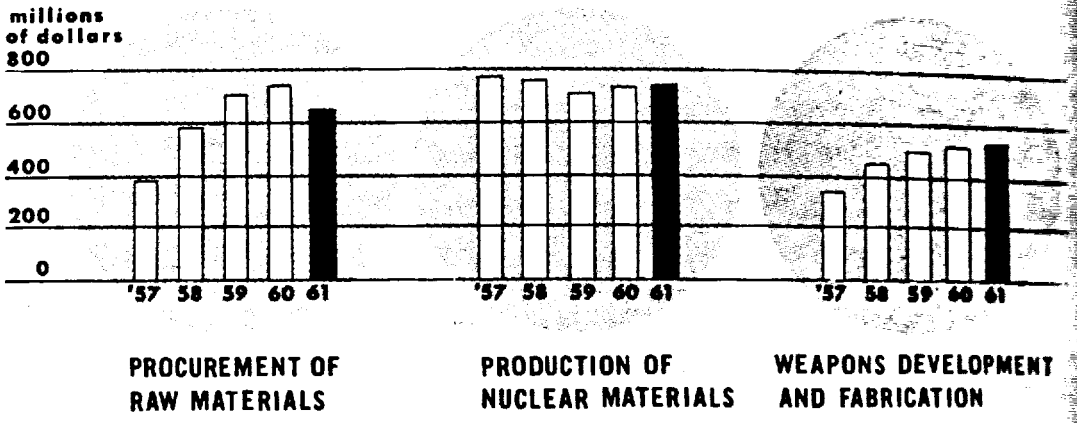
PRODUCTION ACTIVITIES

The cost of procurement of raw materials decreased $80 million to $637 million in fiscal year 1961.

The cost of producing nuclear material increased $2 million to $733 million in fiscal year 1961.

Weapons development and fabrication costs increased $10 million to $516 million in fiscal year 1961.



PROCURE

ium and other raw material
$717 million in 1960.

NIUM CONCENTRATES

total cost of uranium concen
ompared with $704 million i
the total cost of uranium pu
ion of $77 million in U_3O_8 pu
and domestic suppliers to de

table below shows the origin
961 and 1960.

	T 196
U_3O_8 Purchases	(i
Domestic	$3
Canadian	2
Overseas	1
Total	$6

* Bonus payments to r
to fiscal year 1960.

the end of FY 1961 AEC ha
unting to $2.2 billion as sho

U_3

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PROCUREMENT OF RAW MATERIALS

ium and other raw materials procured in fiscal year 1961 cost $637 million as compared $717 million in 1960.

NIUM CONCENTRATES

otal cost of uranium concentrates (U_3O_8) purchased in fiscal year 1961 was $627 million ompared with $704 million in 1960. This is the first year in the atomic energy program the total cost of uranium purchased decreased from that of the preceding years. The re- on of $77 million in U_3O_8 purchases was due principally to arrangements with the Cana- and domestic suppliers to defer delivery of material until after April 1, 1962.

able below shows the origin of AEC's procurement in millions of dollars and tons of U_3O_8 61 and 1960.

	Total Cost		Quantity		Average Cost	
	1961	1960	1961	1960	1961	1960
U_3O_8 Purchases	*(in millions)*		*(tons U_3O_8)*		*(dollars per lb.)*	
Domestic	$303	$297*	17,758	16,567	$ 8.54	$ 8.99
Canadian	224	297	10,251	13,443	10.91	11.04
Overseas	100	110	4,251	4,572	11.78	12.01
Total	$627	$704	32,260	34,582	$ 9.72	$10.19

*Bonus payments to miners for initial production of ore were not made subsequent to fiscal year 1960.

he end of FY 1961 AEC had commitments for the procurement of 128,000 tons of U_3O_8 unting to $2.2 billion as shown below.

U_3O_8 PROCUREMENT COMMITMENTS

(in millions)

Domestic	$1,477
Canadian	361
Overseas	389
Total	$2,227

5007645

RESEARCH AND DEVELOPMENT ACTIVITIES

- The cost of developing nuclear reactors in fiscal year 1961 was $437 million. 1961 costs increased $38 million over 1960.

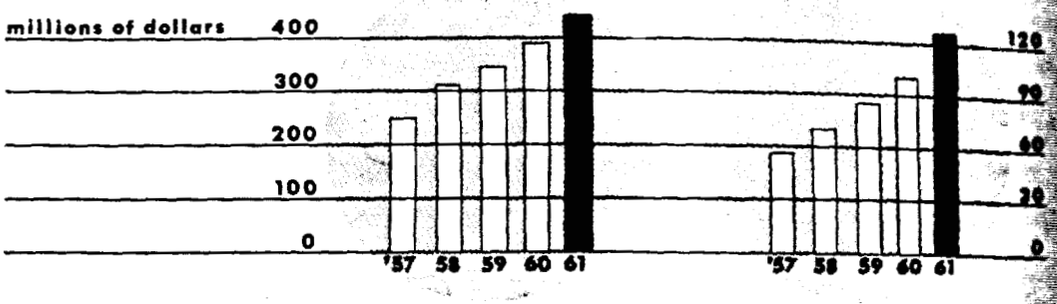
  The cost of developing civilian power reactors increased $2.3 million to $102.3 million.

  The cost of developing nuclear power for satellites, missiles and small power sources increased $22.3 million to $65.5 million. (See chart on next page.)

  The cost of developing nuclear power for military reactors increased $7.6 million to $178.1 million.

- The cost of research in chemistry, physics and metallurgy increased 23% to $124 million in fiscal year 1961.

  The 33 BEV alternating gradient proton-synchrotron at Brookhaven was dedicated early in fiscal year 1961.



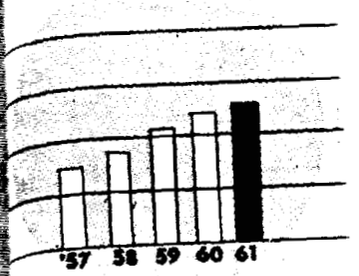
REACTOR DEVELOPMENT

CHEMICAL, PHYSICAL AND METALLURGICAL

FINANCIAL

- The cost of biolog
  million in fiscal ye

- The cost of fusion p
  in fiscal year 1961.
  operations.



BIOLOGY AND MEDICINE

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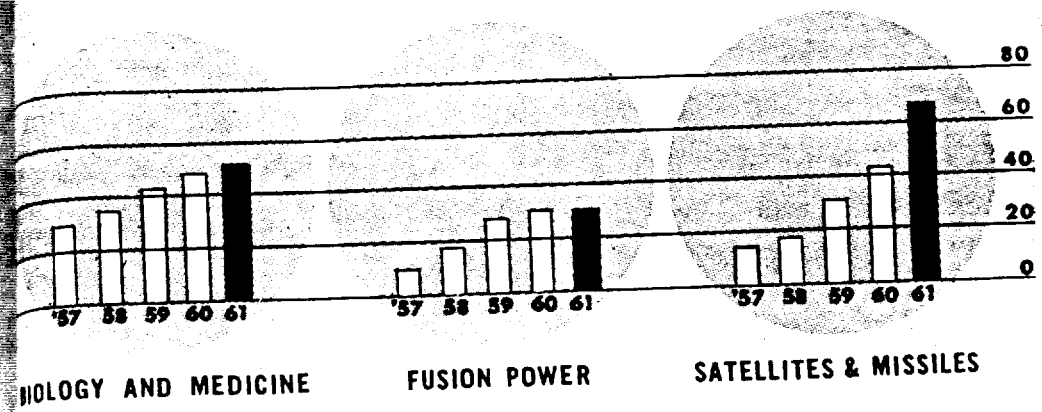
- The cost of biology and medicine research increased 10.2% to $54 million in fiscal year 1961.

- The cost of fusion power research decreased $2 million to $30 million in fiscal year 1961. The C Stellarator device at Princeton commenced operations.



120
90
60
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REACTOR DEVELOPMENT

Development of nuclear reactors for both civilian and military uses received major attention by AEC in fiscal year 1961. The cost of reactor development increased from $399 million in 1960 to $437 million in 1961.

General Reactor Research and Development

Research and development effort on general reactor systems, fuel and fuel cycles, fuel element separations systems, and disposal of radioactive wastes cost $86 million in fiscal year 1961, an increase of $5 million over 1960.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Reactor fuels and materials development	$19,718	$17,359
Engineering physics and advanced reactor development	33,093	29,346
Reactor components development	2,656	2,624
Fuel element separations systems development	6,570	7,218
Waste storage and disposal systems	2,468	4,700
Reactor safety	12,124	10,205
Operations of service facilities and miscellaneous	9,444	9,852
Total	$86,073	$81,304

tor Development Cos

	Resea Cumul Thro June 30
LIAN NUCLEAR POWER REACTORS†	
essurized light water	$ 15
iling light water	5
avy water	2
ganic moderated	3
s cooled	5
dium cooled	13
her studies & development	
Total	45
Y REACTORS	4
CRAFT REACTORS‡	47
AL REACTORS	65
RCHANT SHIP EACTORS	1
SILE AND SPACE PROPULSION	
Rocket (Project Rover)	7
Ramjet (Project Pluto)	5
Total	13
TELLITE AND SMALL POWER SOURCES	4
NERAL	65
tal Reactor Development Costs	$2,46

*Includes AEC depreciation but do
†Does not include costs of privat
ogram.
‡The Aircraft Nuclear Propulsion

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tor Development Cost Summary

	Research and Development Costs*			Capital Plant and Equipment June 30, 1961		
	Cumulative Through June 30, 1961	Fiscal Year 1961	Fiscal Year 1960	Completed Plant	Construction in Progress	Total
	(in millions)			*(in millions)*		
IAN NUCLEAR OWER REACTORS†						
essurized light vater	$ 151.2	$ 26.2	$ 22.1	$ 49.2	$ 1.9	$ 51.1
iling light vater	51.7	11.9	10.5	7.2	12.4	19.6
avy water	27.7	9.3	10.1	1.2	8.9	10.1
ganic moderated	32.1	8.2	8.4	3.8	11.2	15.0
s cooled	53.7	21.4	19.0	.4	19.5	19.9
dium cooled	133.3	22.2	27.5	13.7	52.4	66.1
her studies & development	7.4	3.1	2.4	.1		.1
Total	457.1	102.3	100.0	75.6	106.3	181.9
Y REACTORS	45.4	13.5	12.0	5.2	7.1	12.3
RAFT REACTORS‡	472.4	71.1	69.7	53.2	.9	54.1
AL REACTORS	650.3	93.5	88.8	201.3	36.7	238.0
CHANT SHIP EACTORS	13.8	5.3	4.2		20.4	20.4
SILE AND SPACE PROPULSION						
cket (Project Rover)	74.2	25.2	15.4	14.8	14.1	28.9
mjet (Project Pluto)	57.9	23.0	16.3	4.0	6.7	10.7
Total	132.1	48.2	31.7	18.8	20.8	39.6
ELLITE AND SMALL OWER SOURCES	41.7	17.3	11.5	4.9	1.6	6.5
ERAL	650.8	86.1	81.4	211.7	19.6	231.3
l Reactor Development Costs	$2,463.6	$437.3	$399.3	$570.7	$213.4	$784.1

*Includes AEC depreciation but does not include funding by other Federal agencies.

†Does not include costs of private organizations participating in the power demonstration reactor gram.

‡The Aircraft Nuclear Propulsion Program was discontinued in fiscal year 1961.

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Cooperative Power Reactor Projects

In its Power Demonstration Reactor Program the Atomic Energy Commission cooperates with other organizations – both private and public – in nuclear power plant demonstration projects.

The table below and on the next page shows AEC and private industry participation in cooperative projects for the development and construction of nuclear power plants.

	Date of Criticality and Plant Capacity ekw (net)	Cumulative June 30, 1961		Total Estimated	
		AEC Assistance	Participant's Costs*	AEC Assistance†	Participant's Costs*
		(in millions)			
Yankee Atomic Electric Co. Rowe, Mass.	Commenced Operations July 1961* 141,000 ekw				
Research and development		$ 4.9	$ .2	$ 5.0	$ .2
Plant, equipment and land			39.6		40.4
Waiver of use charges		1.0		3.7	
Fuel fabrication			1.6		3.1
Total		5.9	41.4	8.7	43.7
Power Reactor Development Co., Lagoona Beach., Michigan	January 1962 94,000 ekw*				
Research and development		2.6	20.7	3.6	23.2
Plant, equipment and land			55.4		57.5
Waiver of use charges		1.9		3.7	
Fuel fabrication			3.2		3.6
Total		4.5	79.3	7.3	84.3
Rural Cooperative Power Association, Elk River, Minnesota	January 1962 22,000 ekw				
Plant, equipment and land		8.1	1.6	9.3	1.6
Fuel fabrication		.3		.5	
Total		8.4	1.6	9.8	1.6
City of Piqua Piqua, Ohio	December 1961 11,400 ekw				
Research and development		3.5		3.5	
Plant, equipment and land		6.3	3.8	8.3	3.9
Fuel fabrication		.8		1.2	
Total		10.6	3.8	13.0	3.9
Consumers Public Power District, Hallam, Nebr.	March 1962 75,000 ekw				
Research and development		14.8		16.0	
Plant, equipment and land		25.6	18.1	28.9	20.6
Fuel fabrication		1.1		2.9	
Total		41.5	18.1	47.8	20.6

Northern States Power Co. Sioux Falls, S. D.				
Research and development				
Plant, equipment and land				
Waiver of use charges				
Fuel fabrication				
Total				
Carolinas-Virginia Nuclear Power Assoc., Inc. Parr, South Carolina				
Research and development				
Plant, equipment and land				
Waiver of use charges				
Fuel fabrication				
Total				
Consumers Power Co. of Michigan Big Rock Point, Mich.				
Research and development				
Plant, equipment and land				
Waiver of use charges				
Total				
Philadelphia Electric Co. York County, Pa.				
Research and development				
Plant, equipment and land				
Waiver of use charges				
Fuel fabrication				
Total				
Puerto Rico Water Resources Authority, Punta Higuera Puerto Rico				
Research and development				
Plant, equipment and land				
Fuel Fabrication				
Total				
Summary				
Research and development				
Plant, equipment and land				
Fuel fabrication				
Waiver of use charges				
Total				

*As reported by participant
†Includes estimated costs f

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	Date of Criticality and Plant Capacity ekw (net)	Cumulative June 30, 1961		Total Estimated	
		AEC Assistance	Participant's Costs*	AEC Assistance†	Participant's Costs*
		(in millions)			
Northern States Power Co. Sioux Falls, S. D.	June 1962 62,000 ekw*				
Research and development		$ 5.9	$ .2	$ 8.3	$ .2
Plant, equipment and land			14.3		22.4
Waiver of use charges		.3		1.8	
Fuel fabrication			.1		3.5
Total		6.2	14.6	10.1	26.1
Carolinas-Virginia Nuclear Power Assoc., Inc. Parr, South Carolina	August 1962 16,950 ekw*				
Research and development		6.9	.9	13.9	2.9
Plant, equipment and land			5.2		17.7
Waiver of use charges				1.2	
Fuel fabrication					3.0
Total		6.9	6.1	15.1	23.6
Consumers Power Co. of Michigan Big Rock Point, Mich.	September 1962 47,808 ekw*				
Research and development		1.2		4.2	
Plant, equipment and land			10.6		27.6
Waiver of use charges				1.7	
Total		1.2	10.6	5.9	27.6
Philadelphia Electric Co. York County, Pa.	June 1964 40,015 ekw*				
Research and development		12.5	1.5	14.5	5.6
Plant, equipment and land			3.1		29.2
Waiver of use charges		.1		2.5	
Fuel fabrication					1.0
Total		12.6	4.6	17.0	35.8
Puerto Rico Water Resources Authority, Punta Higuera Puerto Rico	December 1962 16,300 ekw*				
Research and development		1.1	.3	1.4	.3
Plant, equipment and land		3.6	1.3	9.3	3.5
Fuel Fabrication				.8	
Total		4.7	1.6	11.5	3.8
Summary	526,473 ekw				
Research and development		53.4	23.8	70.4	32.4
Plant, equipment and land		43.6	153.0	55.8	224.4
Fuel fabrication		2.2	4.9	5.4	14.2
Waiver of use charges		3.3		14.6	
Total		$102.5	$181.7	$146.2	$271.0

*As reported by participant.
†Includes estimated costs for five years after operations commence.

5007651

Satellite and Small Power Sources

The cost of research and development of reliable, lightweight sources of auxiliary power for space vehicles and for other applications amounted to $17 million in fiscal year 1961 compared with $11 million in 1960.

The table below shows a comparison of 1961 and 1960 research and development costs for auxiliary radioisotope and reactor space power systems.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Radioisotope power systems	$ 2,919	$ 3,100
Reactor space power systems	14,323	8,380
Total	$17,242	$11,480

Missile and Space Propulsion Reactors

AEC cost of research and development of missile and space propulsion systems increased to $48 million in fiscal year 1961 from $32 million in 1960, an increase of $16 million.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Rocket (Project Rover–Space)	$25,143	$15,462
Ramjet (Project Pluto–Missile)	23,080	16,315
Total	$48,223	$31,777

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re the major physical researc

following table shows a com
1960.

Fusion power researc
High energy physics
Chemical properties a
Nuclear structure and
Metallurgy and materi
Systems and material
Physical and chemical
separation
Computer research an
Other physical resear
Total

usion Power Research

fiscal year 1961, the cost of t
r the production of power was
proaches to the problem are
r these various approaches for

Stellarator
Magnetic mirror
Direct current experi
Relativistic electron
Pinch, magnetic shoc
and rotating plasma
General research and
Total

5007652

PHYSICAL RESEARCH

estigations of the laws of nature, including neutron physics, elementary-particle physics, clear structures, materials related research, and research effort to harness fusion energy re the major physical research areas in fiscal year 1961.

e following table shows a comparison of costs in major scientific areas for fiscal years 1961 d 1960.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Fusion power research	$ 30,136	$ 32,148
High energy physics	47,521	32,263
Chemical properties and reactions	25,166	23,116
Nuclear structure and neutron physics	19,757	17,894
Metallurgy and materials research	15,344	12,672
Systems and materials chemistry	5,333	5,811
Physical and chemical methods of isotope separation	1,927	2,405
Computer research and development	3,489	2,856
Other physical research	5,432	3,680
Total	$154,105	$132,845

usion Power Research

fiscal year 1961, the cost of the program leading to the future development of fusion energy r the production of power was $30 million compared to $32 million in 1960. Several different proaches to the problem are being made. The table below shows a comparison of the costs r these various approaches for fiscal years 1961 and 1960.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Stellarator	$11,040	$14,483
Magnetic mirror	3,528	2,907
Direct current experiment	6,552	5,575
Relativistic electron	789	1,068
Pinch, magnetic shock compression, and rotating plasma	4,426	3,984
General research and development	3,801	4,131
Total	$30,136	$32,148

5007693

High Energy Physics

Fiscal year 1961 costs of high energy physics were $47.5 million, an increase of $15.2 million or 47 per cent over 1960. The effort in high energy physics centers around attempts to learn as much as possible about the properties of fundamental nuclear particles through research with high energy particle accelerators.

The following table shows a comparison of the costs incurred for fiscal years 1961 and 1960 in high energy physics research using the listed machines or devices.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Princeton-Penn Accelerator 3 BEV*	$ 3,475	$ 1,175
Alternating Gradient Synchrotron 33 BEV†	4,601	772
Cambridge Accelerator 6 BEV*	731	379
Cosmotron 3.2 BEV†	5,123	4,621
Zero Gradient Synchrotron 12.5 BEV*	3,014	2,424
Bevatron 6.2 BEV†	11,466	10,017
184" Cyclotron 740 MEV†	1,672	1,964
California Institute of Technology Accelerator 1.5 BEV†	731	792
Stanford Accelerator‡	3,143	1,018
Other	13,565	9,101
Total	$47,521	$32,263

*Under construction.

†In operation.

‡Authorized by the 87th Congress.

BIOLOGY

cost of AEC biomedical rese
$48.8 million. Increased effo
public safety from radiation h
atomic energy (including its t
ences.

following table shows a com
0.

Somatic effects of radiati
Radiation genetics
Combating detrimental ef
Molecular and cellular le
Environmental radiation s
Radiological and health pl
Chemical toxicity
Nuclear energy civil effe
Cancer research
Beneficial applications

Total

5007654

BIOLOGY AND MEDICINE RESEARCH

cost of AEC biomedical research was $53.8 million in fiscal year 1961. The cost in 1960 $48.8 million. Increased efforts were made in environmental research required to assure public safety from radiation hazards. Research activities have continued in the utilization atomic energy (including its tools and by-products) in the biomedical and agricultural ences.

following table shows a comparison of costs in fields of biomedical research in 1961 and 0.

	Fiscal Year	
	1961	1960
	(in thousands)	
Somatic effects of radiation	$14,047	$11,463
Radiation genetics	4,075	3,579
Combating detrimental effects of radiation	2,147	2,391
Molecular and cellular level studies	9,640	9,247
Environmental radiation studies	8,648	7,061
Radiological and health physics & instrumentation	4,278	4,694
Chemical toxicity	578	561
Nuclear energy civil effects	1,458	1,441
Cancer research	5,137	4,698
Beneficial applications	3,858	3,743
Total	$53,866	$48,878

5007655

RESEARCH LABORATORIES

A major portion of AEC research and development is conducted in government-owned laboratories. The investment in completed AEC-owned research facilities at June 30, 1961 was $1.4 billion. These facilities include research and development reactors, accelerators, and general laboratory buildings, equipment and research devices.

The research and development work conducted in AEC-owned laboratories includes civilian and military reactor design and development; physical research; research in the life sciences; and research to improve nuclear materials production processes and techniques. The ten laboratories shown below are the principal centers of the Commission's research effort. The operating costs of these laboratories together with the costs incurred at other AEC-owned installations and the cost of the work performed in facilities owned by universities, industrial, and other privately-owned organizations are included in the costs of the various research areas shown throughout this report.

AEC LABORATORIES

	Investment in Completed Plant June 30, 1961	Operating Costs 1961	Operating Costs 1960
	(in thousands)		
Los Alamos Scientific Laboratory	$163,660	$ 73,997	$64,660
Argonne National Laboratory	147,841	48,442	44,295
Oak Ridge National Laboratory	161,633	67,610	66,201
Brookhaven National Laboratory	109,678	29,082	23,451
Lawrence Radiation Laboratory	129,391	106,066	90,465
Bettis Atomic Power Laboratory (including Naval Reactor Facility at NRTS, Idaho)	106,962	61,038	57,074
Knolls Atomic Power Laboratory	82,160	45,221	41,388
Ames Research Laboratory	10,022	4,377	4,136
Hanford Laboratory	78,048	32,750	27,428
Savannah River Laboratory	48,417	14,314	13,842

5007656

EDUCATION AND TRAINING

cial assistance to colleges, universities, teachers and students, for the purpose of encour- interest in the curriculum and courses offered in the field of atomic energy, amounted to million in fiscal year 1961. In addition, the AEC has source and special nuclear materials n to educational institutions valued at $10.7 million on which use charges are waived.

	Fiscal Year 1961 *(in thousands)*
Grants for the purchase of equipment	$3,521
Operation of schools and courses	2,299
Training institutes – 680 teachers	1,260
Fellowships – 272 fellows	1,286
Other costs	501
	8,867
Waiver of use charges	378
Security clearances	9
Total	$9,254

ts for the purchase of equipment. Financial assistance in the form of grants for the pur- of training equipment was made to 248 American colleges and universities. The cost was million in fiscal year 1961.

ation of schools and courses. The following table shows the number of students in attend- and the cost of operating two schools and nine courses in the field of nuclear technology.

	Number of Students		Net Operating Cost Fiscal Year 1961
	Foreign	Domestic	*(in thousands)*
Schools:			
International Institute of Nuclear Science and Engineering – ANL	107	4	$ 649
Puerto Rico Nuclear Center	22	72	917
Courses:			
Industrial Applications – Radioisotopes – ORINS	17	108	98
Reactor Supervisors Training Course – Shippingport	19	11	(12)
Nuclear Reactor Operations Supervision Course – ORNL	8	18	70
Nuclear Reactor Hazards Evaluation Course – ORNL	7	1	82
Radioisotopes Special Training Course – ORINS	41	219	181
Traveling Science Teachers Course – ORINS		61	18
Mobile Isotope Training Course – ORINS		141	34
Training Courses for State and Local Government Employees			47
Radiochemical and Counting Procedures Course			3
Total			$2,087*

*After deducting revenue of $212 thousand.

5007657

Activities Supporting Peaceful Uses of Atomic Energy

SALE OF MATERIALS AND SERVICES

Revenue from sales of materials and services for fiscal year 1961 amounted to $16 million compared with $15 million for fiscal year 1960. The table below shows the major sources of this income.

	Fiscal Year 1961	Fiscal Year 1960
	(in thousands)	
Source and special nuclear materials	$ 6,575	$ 4,061
Heavy water	5,560	4,867
Radioisotopes	1,803	2,209
Vanadium pentoxide	209	1,581
Other materials	386	255
Services	983	1,686
Total	$15,516	$14,659

Materials Leased

Source and special nuclear materials and heavy water with licensees and foreign governments increased to $127 million at June 30, 1961 from $99 million at June 30, 1960. These amounts represent the established value of the material. The following table compares the value of source and special nuclear materials and heavy water leased by type of organizations at June 30, 1961 and 1960. It also shows the value of such material which was subject to use charges and the value of material that was exempt from use charges. Use charges waived during fiscal year 1961 were $2.1 million. Use charges earned in 1961 were $2.6 million.

SOURCE AND SPECIAL NUCLEAR MATERIALS AND HEAVY WATER LEASED

	Total Inventory* June 30		Subject to 4% Use Charge June 30		Not Subject to Use Charge June 30	
	1961	1960	1961	1960	1961	1960
	(in thousands)					
Domestic:						
Industrial organizations	$105,579	$82,994	$63,587	$47,816	$41,992	$35,178
Educational and research institutions	10,809	8,074	91	32	10,718	8,042
Other Federal agencies	1,225	903			1,225	903
Foreign countries	9,612	6,731	9,612	6,731		
Total	$127,225	$98,702	$73,290	$54,579	$53,935	$44,123

*At established prices.

5007658

SALES OF RADIOISOTOPES

sotope sales in fiscal year 1961 amounted to $1.8 million as compared to $2.2 million scal year 1960. Foreign sales of radioisotopes decreased to $299 thousand, 21 per cent han in fiscal year 1960.

ollowing table shows a comparison of sales of radioisotopes for fiscal years 1961 and

	Sales			
	Quantity		Dollars	
	1961	1960	1961	1960
	(curies)		(thousands)	
Carbon-14	42	15	$ 398	$ 227
Cobalt-60	71,852	162,684	170	539
Phosphorus-32	134	129	139	148
Iodine-131	290	609	99	216
Polonium-210	1,035	4,610	94	246
Tritium	37,034	15,952	75	32
Krypton-85	3,696	3,515	60	57
Iridium-192	6,309	8,767	40	62
Cesium-137	16,084	72,282	27	123
Thallium-204	14	3	14	3
Technetium-99	38*	2*	5	7
Promethium-147	968	1,648	3	6
Strontium-90	256	239	3	3
All other	-	-	676	540
Total			$1,803	$2,209

*In grams

decrease of $406 thousand in radioisotope revenue was caused by withdrawal of AEC from market for iodine and cobalt because of availability of commercial supplies and reductions prices of several radioisotopes. Excluded from sales are quantities of radioisotopes pro- ed and distributed for use by AEC, among these are the following: 616,000 curies of cobalt- 5,000 curies of cesium-137, and 18,000 curies of strontium-90. As additional radioisotopes ome available commercially, AEC will discontinue supplying such isotopes.

number of licenses granted for use of radioisotopes increased 10 per cent in 1961 as com- ed with 1960. The following table gives a comparison of the number of licensees by type or anization.

ORGANIZATIONS WITH RADIOISOTOPE LICENSES

	June 30	
	1961	1960
Medical institutions and physicians	2,705	2,455
Industrial organizations	1,898	1,724
Federal and state laboratories	1,230	1,152
Colleges and universities	317	277
High schools, foundations, and other institutions	116	106
Total	6,266	5,714

5007659

INDEMNIFICATION

Public Law 85-256, section 170 of the Atomic Energy Act of 1954, provides a means of protecting the public from financial loss due to a catastrophic nuclear incident arising out of the operation of certain nuclear facilities. Since the total loss from such an incident might greatly exceed the amount of private insurance available ($60 million), the AEC is authorized to enter into indemnification agreements with some of its licensees providing public liability protection of $500 million for each incident.

Except for non-profit educational institutions and federal agencies, the operator of a licensed nuclear facility is required to provide some financial protection in order to qualify for the indemnification. The exact amount of financial protection depends on the type of reactor operated and the power level.

As of June 30, 1961 AEC had entered into 57 indemnity agreements. To provide the indemnity protection AEC charges a minimum annual fee of $100. Revenue from the fees in 1961 was $37 thousand.

The following table summarizes the indemnity agreements entered into by AEC, the reactor power level, and the amount of financial protection required of the licensee in order to qualify for the indemnification.

INDEMNITY AGREEMENTS

Organization	Power Level (Thermal)	Financial Protection Required
Yankee Atomic Electric Co.	392,000 KW	$60,000,000
Commonwealth Edison Company	315,000 KW	60,000,000
General Electric Company	50,000 KW 33,000 KW	12,000,000
Westinghouse Electric Corporation	60,000 KW	12,600,000
Industrial Laboratories, Inc. & Columbia University	5,000 KW	2,500,000
Battelle Memorial Institute	1,000 KW	2,500,000
Western New York Nuclear Research Center, Inc.	1,000 KW	1,500,000
General Dynamics Corporation	1,000 KW	2,500,000
Babcock & Wilcox Company	450 KW	1,500,000
Armour Research Foundation of Illinois Institute of Technology	75 KW	1,500,000
United Nuclear Corporation	5 KW	1,000,000
North American Aviation, Inc.	10 KW	1,000,000
Aerojet-General Nucleonics	20 W	1,000,000
Allis-Chalmers Manufacturing Co.	100 W	1,000,000
The Martin Company	50 W	1,000,000
Alco Products, Inc.		1,000,000
Power Reactor Development Co.		1,000,000
40 Educational Institutions and Federal Agencies		None

5007660

INTERNATIONAL COOPERATION

The United States carries out a program of international cooperation in the peaceful uses of atomic energy. In large part this program is accomplished through agreement for cooperation with 38 foreign countries, the European Atomic Energy Community (EURATOM), and the International Atomic Energy Agency (IAEA).

An important phase of the cooperative program is the support given to other countries in the construction of research reactors and in the provision of laboratory equipment grants for research training and medical purposes. This phase is financed by Mutual Security Agency funds. Some of these grants are provided through the IAEA to its member states. Through June 30, 1961, AEC had provided grants to foreign countries assisting in the construction of reactors totaling $7.9 million and providing equipment totaling $2.5 million. Of the total of these amounts $4.7 million has been paid and $5.7 million remains to be paid.

Education and training of foreign nationals is summarized on page 17.

The AEC assists foreign governments by making source and special nuclear materials and heavy water available for peaceful uses through arrangements for sale or lease. Sales of these materials amounted to $9.3 million. The following table shows the principal foreign lessors of AEC material and the value of materials leased as of June 30, 1961.

Foreign Countries	Amount
Belgium	$ 260,871
Brazil	222,449
Canada	546,784
Denmark	875,529
France	3,934,183
Germany	618,570
India	840,000
Israel	111,702
Italy	353,701
Japan	389,396
Netherlands	333,443
Spain	224,760
Sweden	272,649
All other	628,192
Total	$9,612,229

5007561

RADIOACTIVE WASTE DISPOSAL

Two interim land burial sites have been established for the disposal of solid, packaged radioactive wastes generated by AEC licensees. The sites are located at the Commission's Oak Ridge National Laboratory grounds, Oak Ridge, Tennessee, and at the National Reactor Testing Station, Idaho Falls, Idaho. Waste burial totaled 74,397 cubic feet in fiscal year 1961 and the revenue from such burials amounted to $57,317. The charges for burial are at a rate of 70 cents per cubic foot with a minimum charge of $21 for 30 cubic feet or less of packaged waste. The table below shows the amount of burials and revenue at each interim site.

	Fiscal Year 1961	
	Cubic Feet of Burials	Revenue
Oak Ridge National Laboratory	64,509	$50,396
National Reactor Testing Station	9,888	6,921
Total	74,397	$57,317

RESEARCH ON USES OF ISOTOPES

The cost of AEC research to develop uses for radioisotopes and high level radiation was $3.7 million in fiscal year 1961. The following table shows the cost of the areas of research for 1961 and 1960.

	Fiscal Year	
	1961	1960
	(in thousands)	
Radioisotope technology	$1,275	$1,615
Radioisotope process research and production development	1,058	1,071
Process radiation	1,142	1,048
Food pasteurization	180	74
Total	$3,655	$3,808

FOOD PRESERVATION

AEC is conducting research to establish the feasibility of extending the refrigerated storage life of selected marine products and fruits by radiation pasteurization. The studies are both from the standpoint of utilization of high level radiation and the effect such radiation has on the material itself. The high level radiation research portion is shown in the table above. The biological portion cost $88,000 in 1961. The total cost in fiscal year 1961 was $268,000. The combined budget of this effort for fiscal year 1962 is $1,400,000.

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A

OSTS INCURRED BY

he following table shows the
llocations of cost to the stat
actors but do not necessarily

Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
District of Columbia
Florida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Virginia
Washington
West Virginia
Wisconsin
Wyoming
Foreign Countries
Total

*Does not include depreciatio

AEC Costs by Location

OSTS INCURRED BY AEC PRIME CONTRACTORS BY LOCATION

following table shows the costs incurred by AEC in fiscal year 1961 in the various states. ocations of cost to the states are made in accordance with the physical location of the con- ctors but do not necessarily represent funds spent in those states.

	Operating Costs*	Plant Acquisition and Construction	Total
		(in thousands)	
Alabama	$ 244	$	$ 244
Alaska	949		949
Arizona	6,163		6,163
Arkansas	320		320
California	207,921	13,931	221,852
Colorado	88,368	2,216	90,584
Connecticut	35,317	643	35,960
Delaware	95		95
District of Columbia	23,479	42	23,521
Florida	20,465	721	21,186
Georgia	780		780
Hawaii	129		129
Idaho	44,163	23,345	67,508
Illinois	68,238	26,334	94,572
Indiana	1,556	24	1,580
Iowa	16,919	1,805	18,724
Kansas	417		417
Kentucky	100,176	1,229	101,405
Louisiana	239	126	365
Maine	160	89	249
Maryland	25,640	795	26,435
Massachusetts	15,187	2,599	17,786
Michigan	3,131		3,131
Minnesota	1,671	2,035	3,706
Mississippi	1,611		1,611
Missouri	112,361	4,223	116,584
Montana	93		93
Nebraska	2,862	15,415	18,277
Nevada	34,104	16,783	50,887
New Hampshire	66		66
New Jersey	18,256	10,530	28,786
New Mexico	380,633	13,680	394,313
New York	100,644	21,151	121,795
North Carolina	4,034		4,034
North Dakota	49		49
Ohio	176,751	9,224	185,975
Oklahoma	587		587
Oregon	797		797
Pennsylvania	62,934	3,504	66,438
Rhode Island	379		379
South Carolina	101,644	14,866	116,510
South Dakota	5,277	57	5,334
Tennessee	249,630	43,901	293,531
Texas	16,450	2,207	18,657
Utah	53,471	92	53,563
Vermont	26		26
Virginia	1,035	159	1,194
Washington	124,491	69,181	193,672
West Virginia	195		195
Wisconsin	4,920		4,920
Wyoming	45,610	2,087	47,697
Foreign Countries	328,053	3,746	331,799
Total	$2,488,690	$306,740	$2,795,430

*Does not include depreciation.

Financial Statements

UNITED STATES ATOMIC ERGY COMMISSION
COMPARATIVE ANCE SHEET

ASSETS	June 30, 1961	June 30, 1960
	(in thousands)	
FUNDS IN U. S. TREASURY	$1,462,842	$1,510,056
ALLOCATIONS FROM OTHER FEDERAL AGENCIES	52,001	105,129
CASH ON HAND AND WITH CONTRACTORS	21,498	25,772
ACCOUNTS RECEIVABLE	14,344	16,906
DUE FROM OTHER FEDERAL AGENCIES	13,068	10,491
INVENTORIES		
Source and nuclear materials leased and at research installations	497,616	408,082
Special reactor material	102,115	102,940
Stores	91,669	93,953
Isotopes	13,420	9,864
Other special materials	19,856	19,910
	724,676	634,749
PLANT		
Completed plant and equipment	7,201,938	7,018,062
Less – Accumulated depreciation	2,209,028	2,005,589
	4,992,910	5,012,473
Construction work in progress	462,798	326,689
	5,455,708	5,339,162
PREPAYMENTS AND SPECIAL DEPOSITS	58,258	47,120
TOTAL ASSETS	$7,802,395	$7,689,385

LIABILITIES AND AE

ILITIES
counts payable and accrued e
vances from other Federal a
nds held for others
ferred credits

TOTAL LIABILITIES

EQUITY, JULY 1

dditions
Funds appropriated – net
Nonreimbursable transfers agencies

eductions
Net cost of operations (less of $114,776 thousand in 1 sand in 1960)
Nonreimbursable transfers agencies
Funds returned to U. S. Tr

C EQUITY, JUNE 30

TOTAL LIABILITIES

he notes on the following pag

5007664

RGY COMMISSION
ANCE SHEET

LIABILITIES AND AEC EQUITY	June 30, 1961	June 30, 1960
	(in thousands)	
ILITIES		
ounts payable and accrued expenses	$ 267,127	$ 262,975
vances from other Federal agencies	55,982	91,547
nds held for others	11,758	9,747
ferred credits	2,334	1,784
TOTAL LIABILITIES	337,201	366,053
EQUITY, JULY 1	7,323,332	7,312,322
ditions		
Funds appropriated–net	2,666,760	2,649,614
Nonreimbursable transfers from other Federal agencies	8,393	3,187
	2,675,153	2,652,801
eductions		
Net cost of operations (less charges to inventories of $114,776 thousand in 1961 and $84,384 thousand in 1960)	2,497,444	2,581,270
Nonreimbursable transfers to other Federal agencies	35,296	60,448
Funds returned to U. S. Treasury	551	73
	2,533,291	2,641,791
C EQUITY, JUNE 30	7,465,194	7,323,332
TOTAL LIABILITIES AND AEC EQUITY	$7,802,395	$7,689,385

he notes on the following page are an integral part of this statement.

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NOTES TO THE BALANCE SHEET

1. The balance sheet does not include in assets:

   a. Certain inventories for security reasons.

   b. 64,751,316 troy ounces of silver loaned to AEC by the Treasurer of the United States for use as electrical conductors in plants. Of this amount, 280,500 troy ounces have been lost in usage and are therefore not returnable. Based on market quotations at June 30, 1961, the value of the silver on hand was $58.9 million. The cost of silver lost, the cost of recovering and processing that on hand and returning it to Treasury is estimated at $571,000.

   c. Plant and equipment on loan from other Federal agencies at June 30, 1961 amounting to $9 million.

   d. Contested claims against others of $772,000.

2. The balance sheet does not include in liabilities:

   a. Contingent liabilities related to contracts for the supply of electric power for the Oak Ridge, Paducah and Portsmouth production facilities. If cancellation notice had been given at June 30, 1961, the estimated liabilities would have amounted to $295 million.

   b. Contingent liabilities as guarantor of loans to the extent of $50 million.

   c. Contingent liabilities for claims against AEC of approximately $11 million.

   d. Commitments for accrued annual leave of AEC employees of $7 million.

   e. Commitments for payment of involuntary termination allowances to employees of the Atomic Bomb Casualty Commission. If terminated at June 30, 1961, the estimated liability would have amounted to $822,000.

   f. Under provisions of Section 66 of the Atomic Energy Act of 1954, AEC has contracts for the delivery of domestic uranium concentrates through March 31, 1962 and has guaranteed minimum prices for uranium ores through March 31, 1962 and concentrates for the period April 1, 1962 to December 31, 1966. Subject to certain specified limitations, a price of $8 per pound has been established for U_3O_8 in concentrates delivered after March 31, 1962 and before December 31, 1966. The Commission also has long-term commitments through 1966 for the purchase of U_3O_8 in concentrates and orange oxide from Canadian and overseas sources. The commitments for procurement of uranium totaled $2.2 billion at June 30, 1961.

   g. Commitments under Section 52 of the Atomic Energy Act of 1954 for the acquisition of special nuclear material within or under the jurisdiction of the United States. The amount of the commitments is $5 million at June 30, 1961, based upon estimates (at the price established for the period ending June 30, 1963) of plutonium to be produced and delivered by domestic licensees during the period for which prices have been established.

   h. Outstanding contracts, purchase orders, and other commitments represented by unpaid obligations of $955 million.

5007666

FINANCIAL

UNITED STA'
COMPARAT

Production
Procurement of raw ma
Production of nuclear n
Weapons development a

Development of nuclear r
Civilian nuclear power
Naval propulsion
Aircraft propulsion
Missile and space prop
Auxiliary power source
Army reactors
Merchant ships
General research and c

Research
Physical research
Biology and medicine r
Peaceful application of
Isotope development

Community Operations
Expenses
Revenues

Sales of materials and se
Cost
Revenue

Education and training
AEC administrative expe
Security investigations
Other expenses
Other income

Net cost of oper

Special items
Transfer of community
Adjustments to costs c

Net cost of oper

*Includes depreciation

UNITED STATES ATOMIC ENERGY COMMISSION
COMPARATIVE STATEMENT OF OPERATIONS

(includes depreciation)

	Fiscal Year Ended June 30, 1961	Fiscal Year Ended June 30, 1960
	(in thousands)	
Production		
Procurement of raw materials	$ 636,832	$ 716,507
Production of nuclear materials	732,524	731,348
Weapons development and fabrication	515,531	505,448
	1,884,887	1,953,303
Development of nuclear reactors		
Civilian nuclear power development	102,305	100,095
Naval propulsion	93,442	88,799
Aircraft propulsion	71,116	69,687
Missile and space propulsion	48,223	31,777
Auxiliary power sources	17,242	11,480
Army reactors	13,532	11,945
Merchant ships	5,341	4,165
General research and development	86,073	81,304
	437,274	399,252
Research		
Physical research	154,105	132,845
Biology and medicine research	53,866	48,878
Peaceful application of nuclear explosives	7,311	6,392
Isotope development	3,655	3,808
	218,937	191,923
Community Operations		
Expenses	10,143	17,582
Revenues	(5,680)	(10,492)
	4,463	7,090
Sales of materials and services		
Cost	13,120	12,039
Revenue	(15,516)	(14,659)
	(2,396)	(2,620)
Education and training	8,867	7,675
AEC administrative expenses	57,350	51,197
Security investigations	6,467	7,057
Other expenses	8,214	9,632
Other income	(8,299)	(5,366)
Net cost of operations*	2,615,764	2,619,143
Special items		
Transfer of community property	1,326	43,958
Adjustments to costs of prior year – net	(4,870)	(2,553)
Net cost of operations – after special items	$2,612,220	$2,665,654

*Includes depreciation of $287 million in 1961 and $284 million in 1960.

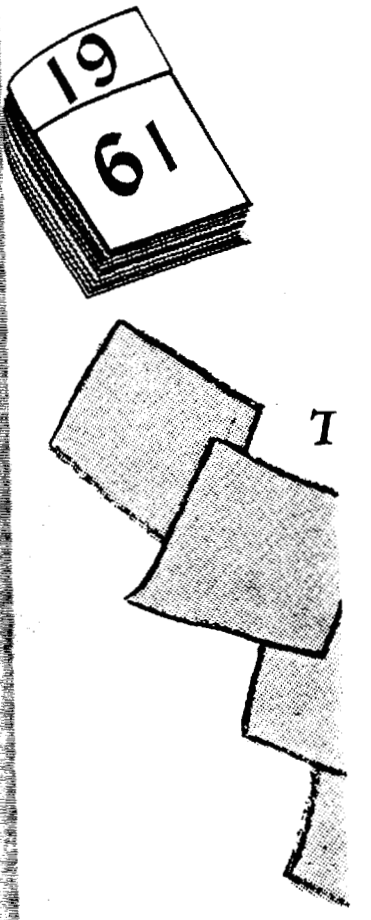
5007667

U. S. GOVERNMENT INVESTMENT IN THE ATOMIC ENERGY PROGRAM

(from June 1940 through June 1961)

	Amount (in millions)	
Appropriation Expenditures:		
National Defense Research Council	$ .5	
Office of Scientific Research and Development	14.6	
War Department (including Manhattan Engineer District)	2,218.3	
		$ 2,233.4
Atomic Energy Commission		
Fiscal Years Prior to 1952	2,705.8	
Fiscal Year 1952	1,669.4	
Fiscal Year 1953	1,812.7	
Fiscal Year 1954	1,930.5	
Fiscal Year 1955	1,861.8	
Fiscal Year 1956	1,633.5	
Fiscal Year 1957	1,931.5	
Fiscal Year 1958	2,268.0	
Fiscal Year 1959	2,541.2	
Fiscal Year 1960	2,622.8	
Fiscal Year 1961	2,713.5	
		23,690.7
Total		25,924.1
Unexpended balance of funds in U. S. Treasury June 30, 1961*		1,462.8
Total funds appropriated		27,386.9
Less		
Collections paid to U. S. Treasury	54.6	
Property and services transferred to other Federal agencies without reimbursement, net of such transfers received from other Federal agencies	172.7	
Cost of operations (including depreciation and obsolescence) from June 1940 through June 30, 1961	19,694.4	
		19,921.7
AEC Equity at June 30, 1961 as shown on Balance Sheet		$ 7,465.2

*Appropriations of $2,547 million for fiscal year 1962 were approved September 1961.



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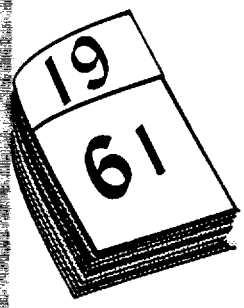
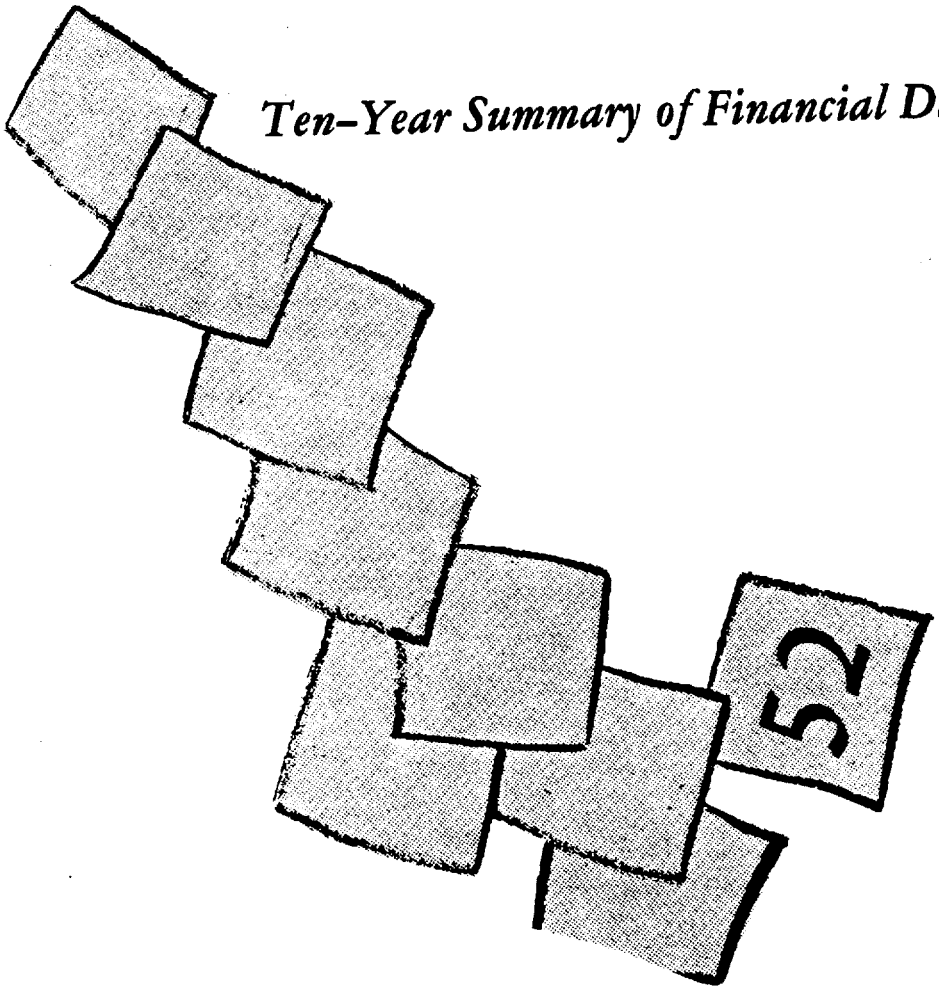


Ten-Year Summary of Financial Data



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UNITED STATES ATOMIC ENERGY COMMISSION TEN-YEAR SUMMAR

(in thousands)

	1961	1960	1959	1958	1957	1956
Cost of operations*	$2,615,764	$2,619,143	$2,496,648	$2,298,589	$1,918,258	$1,607,973
Procurement of raw materials	636,832	716,507	699,996	596,391	397,813	278,946
Production of nuclear materials	732,524	731,348	713,247	750,178	762,815	730,972
Weapons development and fabrication	515,531	505,448	491,981	443,536	337,183	280,765
Development of nuclear reactors	437,274	399,252	355,600	306,225	255,667	168,853
Civilian	102,305	100,095	78,333	52,532	41,996	33,480
Military	201,169	186,745	180,321	173,141	158,366	96,984
Other	133,800	112,412	96,946	80,552	55,305	38,389
Physical research	154,105	132,845	112,318	87,719	69,657	56,547
Fusion power	30,136	32,148	27,685	19,012	11,128	7,066
High energy physics	47,521	32,263	27,517	19,146	17,595	11,981
Other	76,448	68,434	57,116	49,561	40,934	37,500
Biology and medicine research	53,866	48,878	42,781	35,958	33,148	29,849
Community operations–net	4,463	7,090	9,892	11,162	8,897	8,954
Administrative expenses	57,350	51,197	50,135	46,435	38,499	38,195
Miscellaneous expenses and income–net	23,819	26,578	20,698	20,985	14,579	14,892
Plant construction and equipment costs incurred during the year	$ 432,688	$ 331,516	$ 298,979	$ 289,744	$ 317,022	$ 301,682
Total AEC assets excluding inventories of certain products at June 30	$7,802,395	$7,689,385	$7,764,770	$7,652,784	$7,397,911	$7,368,272
Plant investment at June 30 (gross)	$7,664,736	$7,344,751	$7,292,784	$7,110,797	$6,907,896	$6,713,061
Production plants	5,453,568	5,458,201	5,552,646	5,494,440	5,392,464	5,212,776
Research and development facilities	1,434,967	1,271,253	1,124,543	937,682	792,633	753,468
Other	313,403	288,608	365,838	407,529	411,582	499,793
Plant construction in progress at June 30	462,798	326,689	249,757	271,146	311,217	247,024
Funds appropriated–net	$2,666,760	$2,649,614	$2,635,335	$2,333,974	$1,898,700	$ 834,227
Operations	2,456,210	2,387,114	2,385,406	2,225,470	1,740,400	1,146,400†
Plant acquisition and construction	210,550	262,500	249,929	108,504	158,300	(312,173)†
Appropriation expenditures	2,713,465	2,622,838	2,541,181	2,267,960	1,931,485	1,633,549
Employment at June 30	122,989	122,718	121,928	121,059	119,455	110,197
AEC employees	6,846	6,907	6,855	7,107	6,910	6,637
Operating contractor employees	103,313	104,612	105,195	103,290	98,176	90,238
Construction contractor employees	12,830	11,199	9,878	10,662	14,369	13,322

*Includes depreciation.

†Includes transfer to operations of $571 million appropriated in prior years as plant and equipment.

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TEN-YEAR SUMMARY OF FINANCIAL DATA

(thousands)

1957	1956	1955	1954	1953	1952
$1,918,258	$1,607,973	$1,289,535	$1,039,178	$ 904,596	$ 684,181
397,813	278,946	193,586	142,793	82,153	72,510
762,815	730,972	588,445	409,735	318,255	205,746
337,183	280,765	258,706	250,025	257,488	229,178
255,667	168,853	114,557	99,334	104,091	64,448
41,996	33,480	21,364	16,203	6,401	1,603
158,366	96,984	53,011	42,010	53,209	39,501
55,305	38,389	40,182	41,121	44,481	23,344
69,657	56,547	48,221	43,630	41,846	34,671
11,128	7,066	4,718	1,741	800	150
17,595	11,981	8,583	7,802	8,644	5,948
40,934	37,500	34,920	34,087	32,402	28,573
33,148	29,849	28,898	26,974	26,295	24,536
8,897	8,954	10,321	11,822	15,157	16,363
38,499	38,195	34,027	34,671	35,514	31,432
14,579	14,892	12,774	20,194	23,797	5,297
$ 317,022	$ 301,682	$ 842,504	$1,215,141	$1,125,579	$1,082,174
$7,397,911	$7,368,272	$8,077,836	$8,144,414	$8,014,455	$4,692,584
$6,907,896	$6,713,061	$6,487,301	$5,705,405	$4,579,089	$3,496,957
5,392,464	5,212,776	4,645,750	2,957,784	2,118,137	1,327,335
792,633	753,468	707,107	616,548	548,009	338,836
411,582	499,793	505,492	515,939	483,367	467,704
311,217	247,024	628,952	1,615,134	1,429,576	1,363,082
$1,898,700	$ 834,227	$1,209,860	$1,042,492	$4,136,476	$1,605,756
1,740,400	1,146,400†	1,098,978	886,483	808,935	
158,300	(312,173)†	110,882	156,009	3,327,541	
1,931,485	1,633,549	1,861,875	1,930,536	1,812,678	1,669,388
119,455	110,197	112,618	142,021	148,846	149,443
6,910	6,637	6,076	6,195	6,941	6,734
98,176	90,238	82,936	73,312	71,775	58,101
14,369	13,322	23,606	62,514	70,130	84,608

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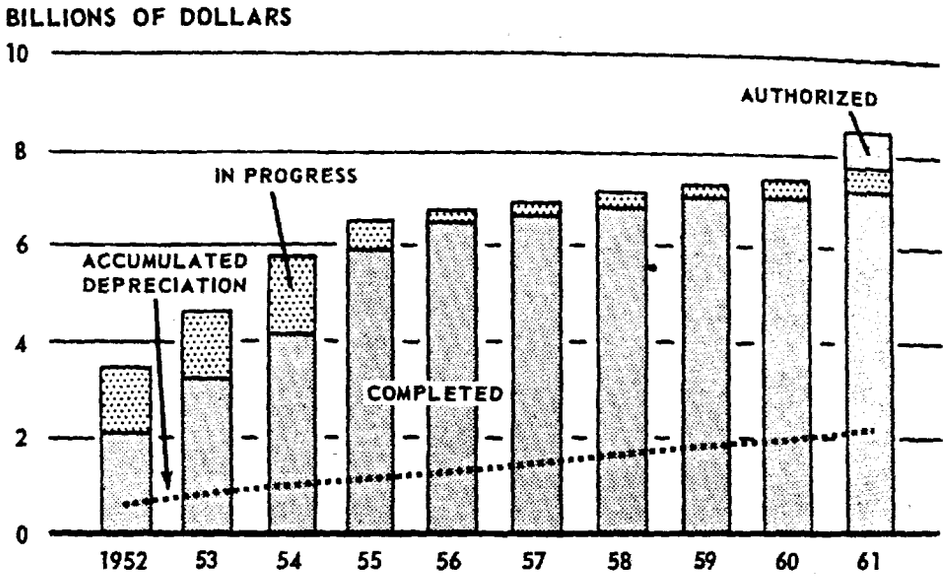
PLANT AND EQUIPMENT

AEC-owned plant and equipment includes plants for the preparation of feed materials; gaseous diffusion plants for the separation of the fissionable isotope uranium-235 from the stable isotope uranium-238; reactors for the production of plutonium, isotopes and other reactor products; facilities for the fabrication and test of weapons; reactors for testing materials and equipment components; reactor prototypes; and research laboratories. AEC-owned plant, at cost, amounted to $7,665 million at June 30, 1961 — $320 million more than at June 30, 1960.

The estimated cost of plant under construction and projects authorized but not started at June 30, 1961 totaled $1,234 million. Costs incurred through June 30, 1961 on plant under construction amounted to $463 million, leaving the estimated costs to be incurred subsequent to June 30, 1961 at $771 million. A major portion of this authorized plant expansion is for construction of reactors and related facilities and for facilities to be used in high energy and controlled thermonuclear research.

The chart below shows the investment in completed plant, accumulated depreciation, and costs incurred on partially completed plant projects at the end of each fiscal year from 1952 through 1961. For fiscal year 1961, the chart also shows plant projects authorized for construction or completion in subsequent periods.

INVESTMENT IN PLANT & EQUIPMENT



INVESTMENT IN PLA

Production
Raw materials
Feed materials
Gaseous diffusion plants
Production reactors and sep
areas
Weapons production and sto
Heavy water
Other production facilities
Total production

Research and development
Laboratories
Reactors
Accelerators
Other research facilities
Total research

Communities
Other
Total

Changes in investment in plar

Investment — June 30, 1960
Construction and equipment c
Additions to completed plant
Plant transfers and retireme
Sale of community facilities
Investment — June 30, 1961

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INVESTMENT IN PLANT AND EQUIPMENT BY TYPE OF FACILITY

(at cost)

June 30, 1961

	Completed Plant	Construction in Progress	Total
		(in thousands)	
Production			
Raw materials	$ 4,047	$ 3	$ 4,050
Feed materials	269,705	11,551	281,256
Gaseous diffusion plants	2,344,784	7,411	2,352,195
Production reactors and separations areas	1,597,748	80,894	1,678,642
Weapons production and storage	837,758	31,190	868,948
Heavy water	163,355	41	163,396
Other production facilities	236,171	5,289	241,460
Total production	5,453,568	136,379	5,589,947
Research and development			
Laboratories	916,966	68,838	985,804
Reactors	359,359	202,336	561,695
Accelerators	128,763	47,321	176,084
Other research facilities	29,879	1,107	30,986
Total research	1,434,967	319,602	1,754,569
Communities	77,837	1,447	79,284
Other	235,566	5,370	240,936
Total	$7,201,938	$462,798	$7,664,736

Changes in investment in plant and equipment during the fiscal year are as follows:

	Completed Plant	Construction in Progress	Total
		(in thousands)	
Investment—June 30, 1960	$7,018,062	$326,689	$7,344,751
Construction and equipment costs		432,688	432,688
Additions to completed plant	296,579	(296,579)	
Plant transfers and retirements	(110,284)		(110,284)
Sale of community facilities by HHFA	(2,419)		(2,419)
Investment—June 30, 1961	$7,201,938	$462,798	$7,664,736

5007673

AEC PLANT AND EQUIPMENT BY LOCATION

(at cost)

June 30, 1961

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
	(in millions)			
CALIFORNIA				
Lawrence Radiation Laboratory, University of California				
Berkeley	$ 42.4	$ 21.7	$ 3.9	$ 68.0
Livermore	87.0	8.7		95.7
Research facilities, Sandia Corporation, Livermore	10.0	1.3		11.3
Medical research facilities, University of California, Los Angeles	1.3			1.3
Salton Sea Base, Sandia Corporation, Salton Sea	7.0			7.0
Research facilities, California Institute of Technology, Pasadena	2.0			2.0
Linear Electron Accelerator, Stanford University, Palo Alto	.3		114.0	114.3
Reactor and research facilities, Atomics International Division, North American Aviation, Inc., Canoga Park	21.0	7.1	4.6	32.7
COLORADO				
Uranium handling, sampling, and general facilities, Lucius Pitkin, Inc., Grand Junction	4.7			4.7
Rocky Flats Plant, Dow Chemical Company, Boulder	75.7	6.9	4.7	87.3
CONNECTICUT				
Connecticut Aircraft Nuclear Engine Laboratory, Pratt and Whitney, Middletown	5.4†‡			5.4
Linear accelerators, Yale University, New Haven	2.3	1.2		3.5
Submarine reactor facilities, Combustion Engineering, Inc., Windsor	14.4	.1		14.5
FLORIDA				
Pinellas Plant, General Electric Company, Clearwater	11.8	.4	.2	12.4
IDAHO				
National Reactor Testing Station				
Phillips Petroleum Company				
Chemical processing plant	55.9	3.8		

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Location and Contrac

IDAHO (Cont'd)
Materials testing react
Advanced test reactor
Engineering test react
Reactor facilities
General facilities

Total

Westinghouse Electric C
Large ship reactor
Submarine thermal re
Other research faciliti

Total

Research facilities, Gen
Electric Company
Reactor facilities, Argon
National Laboratory
Organic moderated react
experiment, North Am
Aviation, Inc.
Knolls Atomic Power La
General Electric Com
Experimental Beryllium
Reactor, General Aton

Total NRTS

ILLINOIS
Argonne National Laborat
University of Chicago, A
Argonne Cancer Research
University of Chicago, C
Materials Research Labor
University of Illinois, Cl
INDIANA
Radiation Laboratory, Uni
Notre Dame, Notre Dam
IOWA
Research Laboratory, Iow
College, Ames
Iowa Ordnance Plant, Mas
Hangar, Burlington
KENTUCKY
Paducah
Gaseous Diffusion Plant.
Union Carbide Nuclea
Feed Materials Plant, U
Carbide Nuclear Com

Total

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
		(in millions)		
IDAHO (Cont'd)				
Materials testing reactor	$ 13.8	$ .7	$	$ 14.5
Advanced test reactor			40.0	40.0
Engineering test reactor	13.2	.1		13.3
Reactor facilities	23.7	14.2	2.9	40.8
General facilities	21.0	2.8		23.8
Total	127.6	21.6	42.9	192.1
Westinghouse Electric Corporation				
Large ship reactor	33.9	1.1		35.0
Submarine thermal reactor	12.0			12.0
Other research facilities	12.5	2.3		14.8
Total	58.4	3.4		61.8
Research facilities, General Electric Company	37.4	1.2		38.6
Reactor facilities, Argonne National Laboratory	5.7	32.0	.1	37.8
Organic moderated reactor experiment, North American Aviation, Inc.	1.9	1.2	6.0	9.1
Knolls Atomic Power Laboratory, General Electric Company	1.8	18.5		20.3
Experimental Beryllium Oxide Reactor, General Atomics			8.0	8.0
Total NRTS	232.8	77.9	57.0	367.7
ILLINOIS				
Argonne National Laboratory University of Chicago, Argonne	142.1	60.5	11.4	214.0
Argonne Cancer Research Hospital, University of Chicago, Chicago	4.8			4.8
Materials Research Laboratory University of Illinois, Champaign			5.6	5.6
INDIANA				
Radiation Laboratory, University of Notre Dame, Notre Dame	.3		2.2	2.5
IOWA				
Research Laboratory, Iowa State College, Ames	10.0	5.6	.2	15.8
Iowa Ordnance Plant, Mason and Hangar, Burlington	32.4§	.8	.3	33.5
KENTUCKY				
Paducah				
Gaseous Diffusion Plant, Union Carbide Nuclear Company	756.2	3.1	1.0	760.3
Feed Materials Plant, Union Carbide Nuclear Company	26.5		.6	27.1
Total	782.7	3.1	1.6	787.4

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Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
		(in millions)		
MARYLAND				
AEC Headquarters, Germantown	$ 17.8	$ .4	$ .3	$ 18.5
MASSACHUSETTS				
Cambridge electron accelerator, Harvard University, Cambridge	5.0	8.1	.5	13.6
Raw materials development laboratory, National Lead Company, Winchester	1.3			1.3
MINNESOTA				
Linear accelerator, University of Minnesota, Minneapolis	1.9†			1.9
Boiling water power reactor, Rural Cooperative Power Association, Elk River		8.9		8.9
MISSOURI				
Kansas City Plant, The Bendix Corporation, Kansas City	33.5¶	8.3	.9	42.7
Feed Materials Plant, Mallinckrodt Chemical Works, Weldon Spring	58.0	1.2	.6	59.8
NEBRASKA				
Sodium graphite power reactor, Consumers Public Power District, Hallam		28.9		28.9
NEVADA				
Mercury				
Nevada Test Site, Reynolds Electrical and Engineering Company	38.8	26.8	15.7	81.3
Research facilities, University of California	3.7	2.8		6.5
Laboratory facilities, Lawrence Radiation Laboratory	2.6	10.4	2.8	15.8
Total Mercury	45.1	40.0	18.5	103.6
Tonopah				
Research facilities, Reynolds Electrical and Engineering Company	.9	.5		1.4
Research facilities, Sandia Corporation	3.0	1.8		4.8
Total Tonopah	3.9	2.3		6.2
NEW JERSEY				
Merchant ship reactor, Camden		27.1		27.1
New Brunswick Laboratory, Atomic Energy Commission, New Brunswick	2.1			2.1

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Location and Contract

NEW JERSEY (Cont'd)
Princeton
Princeton-Pennsylvania p
accelerator, Princeton
University
Model C stellarator facil
Princeton University
Research facilities, Prin
University

Total Princeton

NEW MEXICO
Albuquerque
Lovelace Foundation Lab
Sandia Laboratory, Sandi
Corporation
South Albuquerque Works
Industries, Inc.

Total Albuquerque

Los Alamos
Los Alamos Scientific La
University of Californi
Community and general
nance facilities, The Z
Company
Los Alamos Hospital, Lo
Medical Center, Inc.

Total Los Alamos

NEW YORK
Brookhaven National Labor
Associated Universities,
Upton
New York City
Computing and other res
cilities, New York Uni
Accelerator and researc
Columbia University

Total New York City

Boron plant, Olin Mathiesc
Corp., Niagara Falls
Research laboratory, Univ
Rochester, Rochester

Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
		(in millions)		
NEW JERSEY (Cont'd)				
Princeton				
Princeton-Pennsylvania proton accelerator, Princeton University	$ 6.8	$ 16.9	$ .5	$ 24.2
Model C stellarator facilities, Princeton University	10.0	.1		10.1
Research facilities, Princeton University	3.8	.1		3.9
Total Princeton	20.6	17.1	.5	38.2
NEW MEXICO				
Albuquerque				
Lovelace Foundation Laboratory			2.0	2.0
Sandia Laboratory, Sandia Corporation	80.5	10.9	1.7	93.1
South Albuquerque Works, ACF Industries, Inc.	23.4	.5	.2	24.1
Total Albuquerque	103.9	11.4	3.9	119.2
Los Alamos				
Los Alamos Scientific Laboratory, University of California	159.9	17.3	15.5	192.7
Community and general maintenance facilities, The Zia Company	128.6	2.3	3.7	134.6
Los Alamos Hospital, Los Alamos Medical Center, Inc.	2.9		.1	3.0
Total Los Alamos	291.4	19.6	19.3	330.3
NEW YORK				
Brookhaven National Laboratory, Associated Universities, Inc., Upton	109.7	25.7	23.9	159.3
New York City				
Computing and other research facilities, New York University	1.6		.2	1.8
Accelerator and research facilities, Columbia University	2.0	.8		2.8
Total New York City	3.6	.8	.2	4.6
Boron plant, Olin Mathieson Chemical Corp., Niagara Falls	7.5			7.5
Research laboratory, University of Rochester, Rochester	5.6	.1		5.7

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Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
		(in millions)		
NEW YORK (Cont'd)				
Knolls Atomic Power Laboratory, General Electric Company, Schenectady	$ 42.3	$ 1.2	$	$ 43.5
West Milton	38.0	31.9		69.9
Fuel and Canning Preparation Areas, Sylvania Electric Products, Inc., Hicksville	2.0	.2		2.2
OHIO				
Research facilities, General Electric Company, Lockland	11.1†‡			11.1
Portsmouth				
Portsmouth Gaseous Diffusion Plant, Goodyear Atomic Corporation	755.3	1.5	1.0	757.8
Feed Materials Plant, Goodyear Atomic Corporation	8.0			8.0
Total Portsmouth	763.3	1.5	1.0	765.8
Feed Materials Plant, National Lead Company, Fernald	112.5	6.9	1.0	120.4
Mound Laboratory, Monsanto Chemical Company, Miamisburg	31.7	4.2	.5	36.4
Organic moderated power reactor City of Piqua, Piqua		7.9		7.9
PENNSYLVANIA				
Bettis Plant, Westinghouse Electric Corporation, Pittsburgh	48.5	5.8		54.3
Accelerator and research facilities, Carnegie Institute of Technology, Pittsburgh	1.3			1.3
Pressurized water reactor, Duquesne Light Company, Shippingport	49.2	9.7		58.9
Penn State University Accelerators			1.0	1.0
SOUTH CAROLINA				
Savannah River Plant, E. I. du Pont de Nemours and Co., Inc., Aiken				
Production reactor facilities	598.1	18.5	3.0	619.6
Separations facilities	270.6	16.6	5.5	292.7
Feed materials production facilities	29.5	1.8		31.3
Heavy water production facilities	163.4			163.4
Works laboratory	48.4	11.0		59.4
General facilities	159.9	5.6	3.7	169.2
Total	1,269.9	53.5	12.2	1,335.6

Location and Contractor
NNESSEE
Oak Ridge
Research laboratory, Oak F Institute of Nuclear Studi
Agriculture Research Labo and Farm, University of Tennessee
Experimental gas cooled re
Oak Ridge Gaseous Diffusio Union Carbide Nuclear C
Fabrication and developmer facilities Union Carbide Nuclear Company
Oak Ridge Natural Laborat Union Carbide Nuclear C
Service facilities
Total
EXAS
Pantex Plant, Mason and Hang Amarillo
TAH
Monticello
Uranium ore processing pl Lucius Pitkin, Inc.
Community services, Luciu Pitkin, Inc.
Total
WASHINGTON
Hanford Works, General Elec Company, Hanford
Production reactor facilitie
Separations facilities
Feed materials production facilities
Works laboratory
General facilities
Total
Community Services, General Electric Company, Richlan
WEST VIRGINIA
Huntington pilot plant, Interna Nickel Company, Huntingto

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Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
	(in millions)			
NNESSEE				
ak Ridge				
Research laboratory, Oak Ridge Institute of Nuclear Studies	$ 3.6	$ .2	$	$ 3.8
Agriculture Research Laboratory and Farm, University of Tennessee	1.4	.3		1.7
Experimental gas cooled reactor	.4	40.8		41.2
Oak Ridge Gaseous Diffusion Plant, Union Carbide Nuclear Company	840.7	7.4	1.4	849.5
Fabrication and development facilities, Union Carbide Nuclear Company	387.2	12.2	7.0	406.4
Oak Ridge National Laboratory, Union Carbide Nuclear Company	161.6	43.1	5.0	209.7
Service facilities	20.2	.4	5.2	25.8
Total	1,415.1	104.4	18.6	1,538.1
XAS				
Pantex Plant, Mason and Hanger, Amarillo	26.5§	1.1	.4	28.0
AH				
Monticello				
Uranium ore processing plant, Lucius Pitkin, Inc.	4.4			4.4
Community services, Lucius Pitkin, Inc.	.3			.3
Total	4.7			4.7
ASHINGTON				
Hanford Works, General Electric Company, Hanford				
Production reactor facilities	476.3	156.8	.2	633.3
Separations facilities	202.4	9.3	1.5	213.2
Feed materials production facilities	25.0	7.2		32.2
Works laboratory	78.0	7.9	5.1	91.0
General facilities	151.2	6.3	5.1	162.6
Total	932.9	187.5	11.9	1,132.3
Community Services, General Electric Company, Richland	2.7			2.7
EST VIRGINIA				
Huntington pilot plant, International Nickel Company, Huntington	4.7			4.7

Total
$ 43.5
69.9
2.2
11.1
757.8
8.0
765.8
120.4
36.4
7.9
54.3
1.3
58.9
1.0
619.6
292.7
31.3
163.4
59.4
169.2
1,335.6

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Location and Contractor	Completed Plant and Equipment	Estimated Total Cost of Projects Under Construction	Projects Authorized Construction Not Started*	Total
		(in millions)		
WYOMING				
Army Package Power Reactor No. 2, The Martin Company, Sundance	$ .4	$ 4.0	$	$ 4.4
PUERTO RICO				
Puerto Rico Nuclear Center, University of Puerto Rico, Mayaguez	4.2	.4	.2	4.8
Nuclear superheat power reactor, Punta Higuera		8.8		8.8
JAPAN				
Research facilities, National Academy of Science, Hiroshima	2.1	.1		2.2
ALL OTHER				
Weapons storage facilities	186.5*•	.8		187.3
Other	51.1	9.1	78.4	138.6
Total	$7,202.0	$834.2	$399.5	$8,435.7

*Includes plant projects authorized in Public Law 87-315 approved September 26, 1961.
†Equipment only.
‡Basic plant owned by U. S. Air Force.
§Basic plant owned by U. S. Army.
¶Basic plant owned by U. S. Navy.
**Approval given in August 1961 to turn these facilities over to DOD.

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United States. Atomic Energy
Commission.

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